AMERICAN ENGINEER AND RAILROAD JOURNAL

NEW YORK [ETC.]

V. 82, 1908

ESTABLISHED 1832.

AMERICAN ENGINEER AND RAILROAD JOURNAL.

R. M. VAN ARSDALE, Proprietor.
J. S. BONSALL, Business Manager.

Editors { R. V. WRIGHT
E. A. AVERILL

Published Monthly at 140 Nassau Street, New York.

INDEX TO VOLUME LXXXII—1908

* indicates illustrated article.
§ indicates editorial comment.
‡ indicates communication.
† indicates a short non-illustrated article or note.

6205
V.82

(Established 1832).
AMERICAN ENGINEER AND RAILROAD JOURNAL.

JANUARY, 1908.

REPAIRING STEEL FREIGHT CARS.

PITTSBURGH & LAKE ERIE RAILROAD—McKEES ROCKS, PA.

The Pittsburgh & Lake Erie Railroad was one of the first to use steel freight cars extensively. Located in the heart of the Pittsburgh district and having a heavy traffic of coal and coke in one direction and iron ore in the other, in addition to the products of the manufacturing plants along its lines, it has been able to use steel freight cars to special advantage.

The methods of maintaining and repairing these cars are in marked contrast to those used on the Baltimore & Ohio Railroad, as described at length in our May, 1907, issue. It will be recalled that the heavy repairs on the Baltimore & Ohio, at Mt. Clare, were made in the open with very few special facilities and no overhead cranes, and that the painting of the cars was done by hand. At the McKees Rocks shops of the Pittsburgh & Lake Erie a large building with traveling cranes has been provided so that repairs may be carried on expeditiously and without interruption during inclement weather. This building is used for heavy repairs of both steel and wooden equipment, but eventually will be entirely devoted to steel car work. A number of special devices have been provided to facilitate work on the steel cars and a comparatively large stock of finished material is carried so that damaged parts may be replaced immediately, making it possible to get the cars back into service without delay. The costs of repairing and scraping badly damaged parts are compared and the least expensive course followed. A spraying machine is used for painting the cars, thus effecting a considerable saving in time, labor and material.

At the present time 54.7 per cent. of the total freight car equipment is of steel construction. This includes 4,174 twin hopper gondola cars, 3,216 hopper cars, 1,600 coke cars, 117 flat cars and 250 composite gondola cars with steel underframes. As with the Baltimore & Ohio, some of the first cars which were introduced, when the art of steel car design was in its infancy, proved defective in certain respects, but in all cases this was overcome by reinforcing the weak parts. The designs have gradually been perfected until to-day very little difficulty is experienced with the steel cars under normal conditions, and these conditions are especially severe when we consider the method of loading coal cars and of unloading them at the docks; the reloading of the cars with ore, which in most cases is carried directly over the hopper doors, and the carrying of pig iron and hot billets.

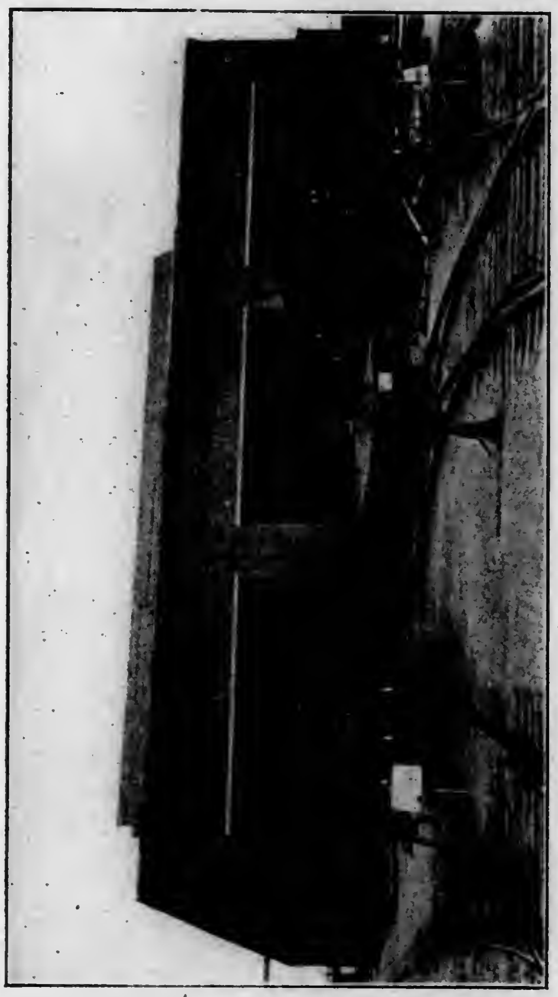
The car department repair plant lies just north of the locomotive repair shops, the general plan of which was considered on page 395 of our November, 1903, issue. The machine and erecting shops of the old locomotive repair plant were remodeled, after the new shops were built, and one is now used as a cab and tender shop and the other as a coach shop, as shown on the accompanying plan. The coaches, when ready for painting, are transferred to the paint shop at the western corner of the locomotive plant. The freight car repair department lies directly to the north of the coach shop. The freight car shop at present is 418 ft. 9½ in. long, but provision is made for its future extension to 654 ft. 7 in., as shown on the plan view of the building. It will accommodate 48 cars for heavy repairs, allowing 52 ft. to a car. There is room just north of the shop for 42 additional cars; north of the bridge extending over the tracks is a light repair yard, which will accommodate 100 cars, also a space which is devoted to the repainting of cars. Lying alongside of the light repair yard is a stock house at one end and a scrap platform at about the middle, where provision is made for removing coupler yokes and riveting them to new couplers, also for relining journal boxes. All old bolts and nuts are worked over on bolt threading and nut tapping machines and a post hammer and shears are provided for straightening and cutting them to length before re-threading them. A lumber storage shop and a woodworking shop are located alongside of the freight car shop and nearest to that part which is devoted to wooden car repairs. Material is delivered from one part of the plant to another over a system of standard gauge industrial tracks.

The car repair shop is of brick construction with steel framing and rests upon concrete foundations. The main portion of it is 418 ft. 9½ in. long by 154 ft. wide and is divided into three bays, each having two repair tracks, with a material track between. On the side of the shop devoted to steel car repairs is an extension, or additional bay, 23 ft. wide and 312 ft. 9½ in. long. Finished steel car parts are stored here and a furnace and machinery for repairing defective parts, or manufacturing new ones, also occupy part of this space. The construction of the building, together with the arrangement of the sawtooth roof, is shown in the accompanying drawings and photographs. The windows in the skylights are vertical and face toward the north, so that a plentiful supply of diffused light is admitted from above. In addition there is a large amount of window space in the side walls. Electric arc lights furnish artificial light. The building is heated with hot air by the Sturtevant system, the fans and heating apparatus being located in the extension of the building, as shown. The delivery pipes are carried overhead with downdrop outlets at proper intervals. Provision has been made to maintain a temperature of 50 degrees Fahr. during winter weather.

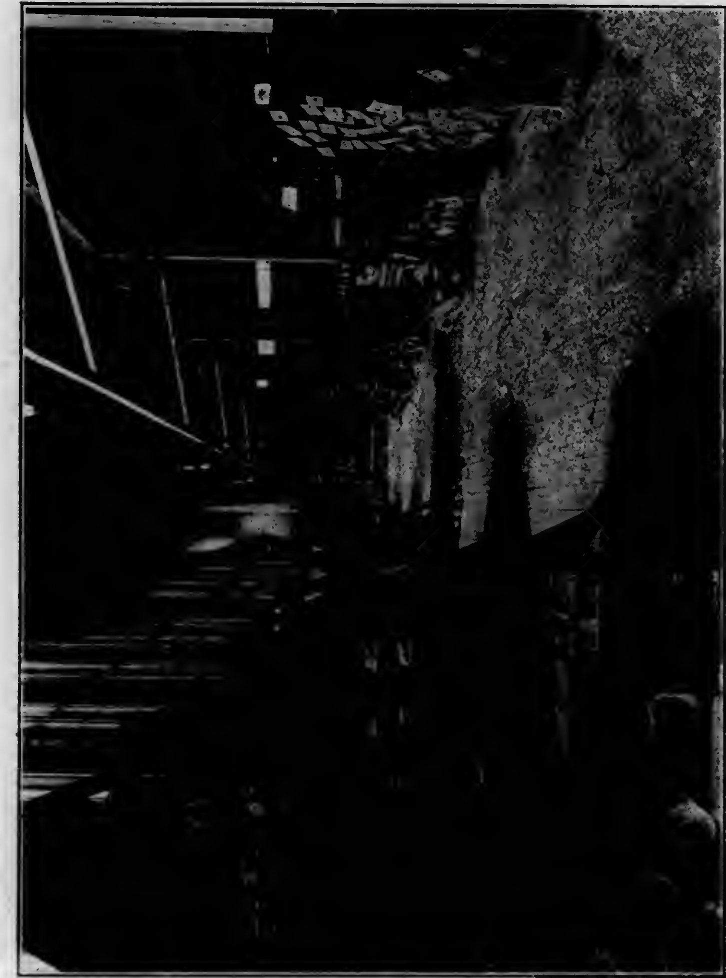
The two outer bays in the main part of the shop measure 53 ft. from the outside walls to the center of the row of columns, while the middle bay measures 48 ft. center to center of the columns. The repair tracks are spaced 24 ft. center to center and the two outer tracks measure 16 ft. from the inside of the wall to the center of the track. The underside of the roof trusses is 30 ft. from the floor. A 20-ton Shaw crane operates over the bay which is devoted to steel car repairs. The other two bays are used principally for heavy wooden car repairs, the middle bay being served by a 20-ton crane and the outer one by a 40-ton crane. The outer bay is used extensively for repairing loaded cars, and it is for this reason that the heavier crane is provided. The floor of the building, except for a small space near the furnace, which is of brick, is of 1⅞-in. plank laid on 4 x 4-in. sleepers spaced 30 in. center to center. These are laid on 6 inches of sand or gravel.

There are natural gas and compressed air connections at each column on either side of the bay used for steel car repairs. The natural gas is used in special burners for heating damaged parts without removing them from the car. Compressed air connections are provided at each column alongside of the bays for wooden car repairs.

The apparatus used in connection with the steel car repair work, and located in the addition which practically forms a fourth bay and opens directly into the main part of the shop, consists of a furnace made by the Pittsburg Stoker Company, which uses fuel oil and has a capacity for 5,000 lbs. of steel parts. As has been stated, the distorted parts are cut off the cars and new ones from stock are applied. The damaged parts, if they are suitable for repair, are placed alongside the furnace and when a sufficient amount has accumulated they are piled inside, heated and repaired. At present it is only necessary to operate this furnace about two days of each week. A large open fire is provided for rush or emergency work. Just in front of the furnace is a large face plate on which plates or other parts may be straightened. The flanging clamp shown in one of the illustrations is operated by air and is provided with several dies and formers for straightening and manufacturing the larger parts such as draft sills, etc. An air press, which is used for bending the smaller pieces and is also equipped with a number of simple dies and formers for repairing old parts, or the manufacture of new ones, is also illustrated. A large drill press has been added which is not shown. Beyond the flanging clamp is an air oper-

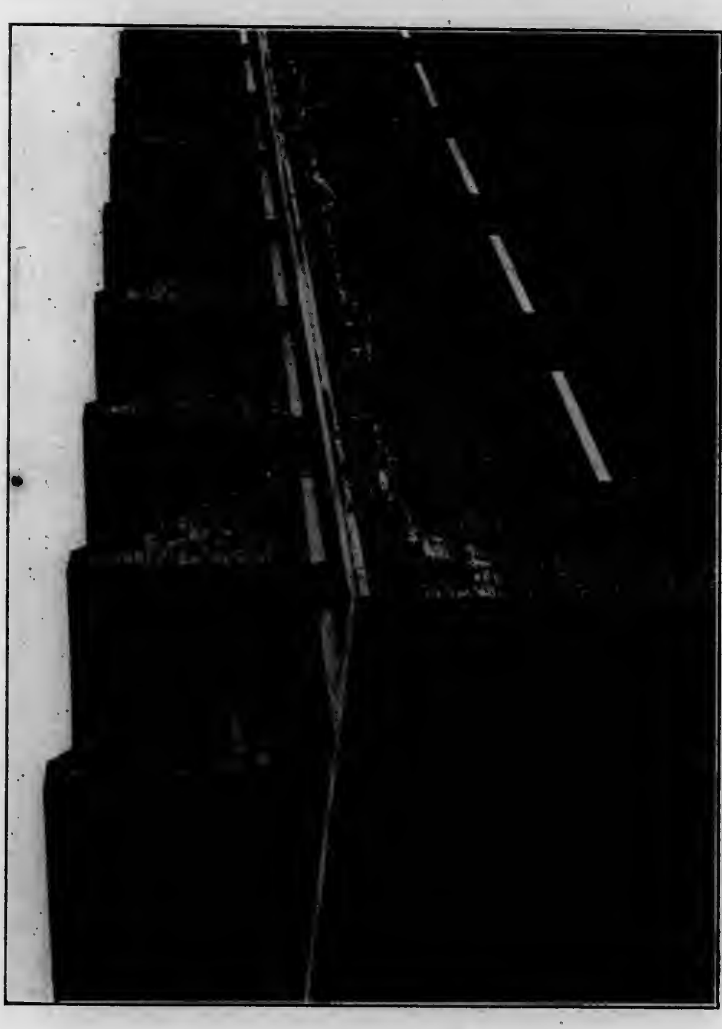


SOUTH END OF THE FREIGHT CAR REPAIR SHOP.



STORAGE SPACE FOR STEEL CAR REPAIR PARTS.

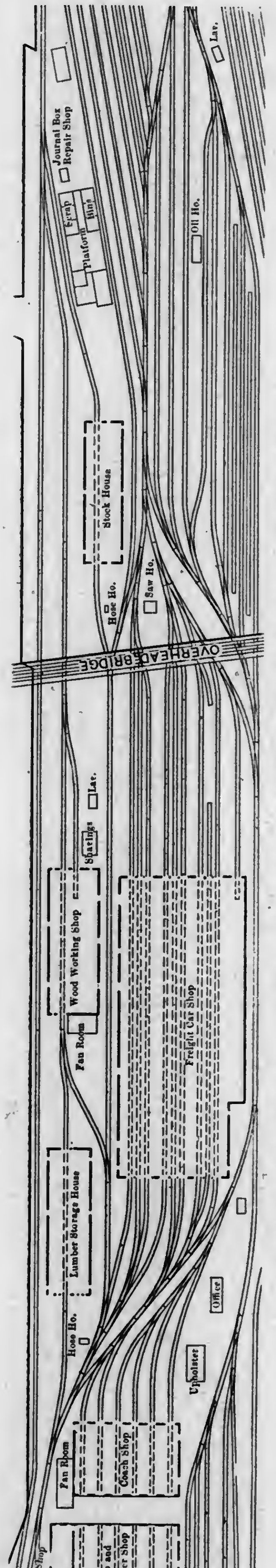
LOOKING DOWN THE MIDDLE BAY OF THE FREIGHT CAR REPAIR SHOP.



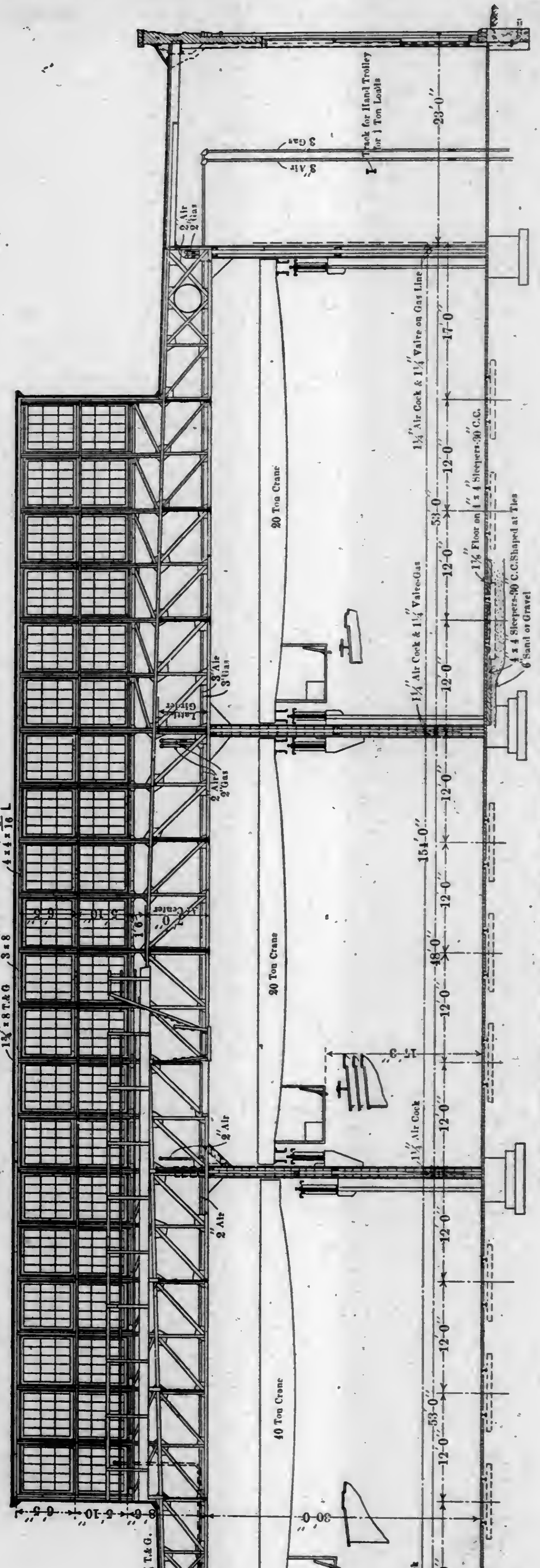
ROOF CONSTRUCTION OF THE FREIGHT CAR REPAIR SHOP.

ROOF CONSTRUCTION OF THE FREIGHT CAR REPAIR SHOP.

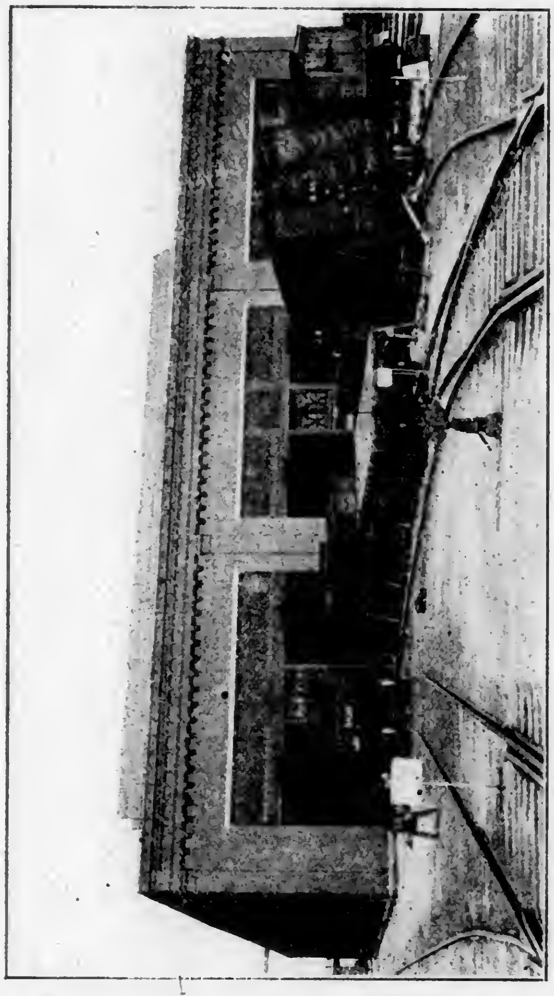
STORAGE SPACE FOR STEEL CAR REPAIR PARTS.



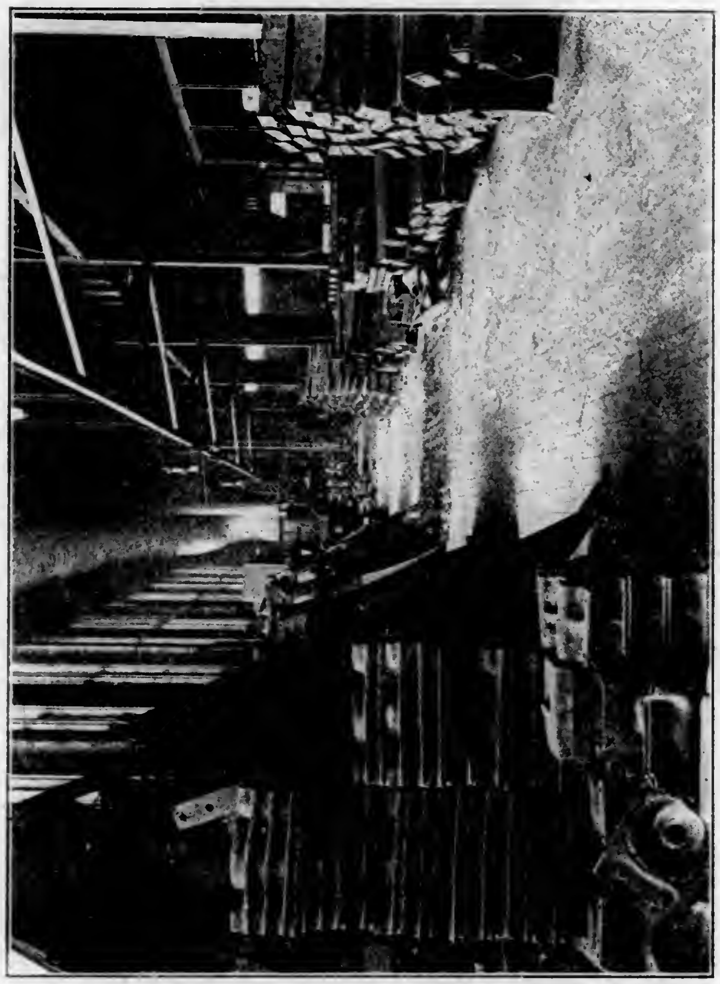
GENERAL PLAN OF THE PITTSBURGH & LAKE ERIE RAILROAD CAR REPAIR DEPARTMENT, MCKEES ROCKS, PA.



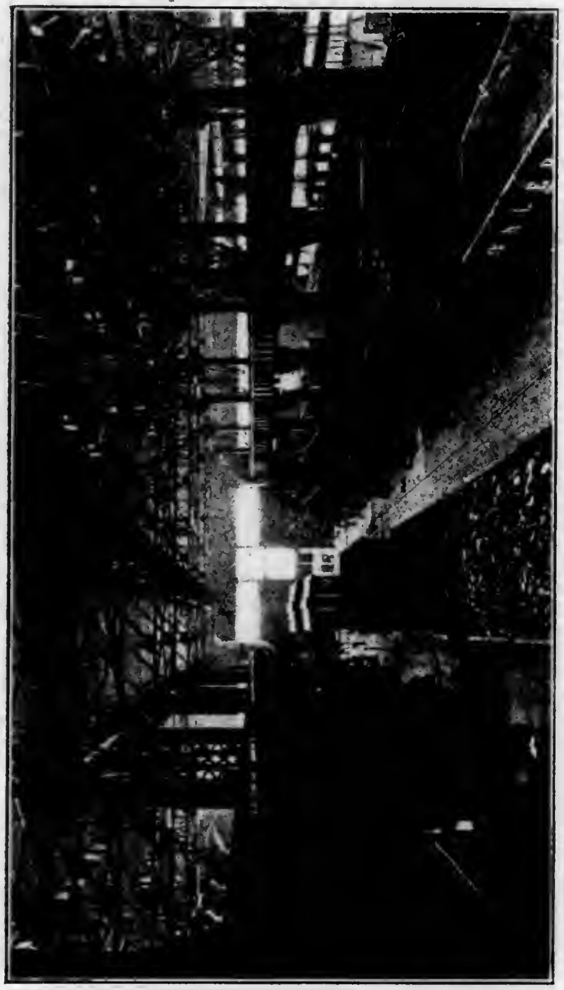
CROSS-SECTION THROUGH THE FREIGHT CAR REPAIR SHOP AT MCKEES ROCKS, PA.



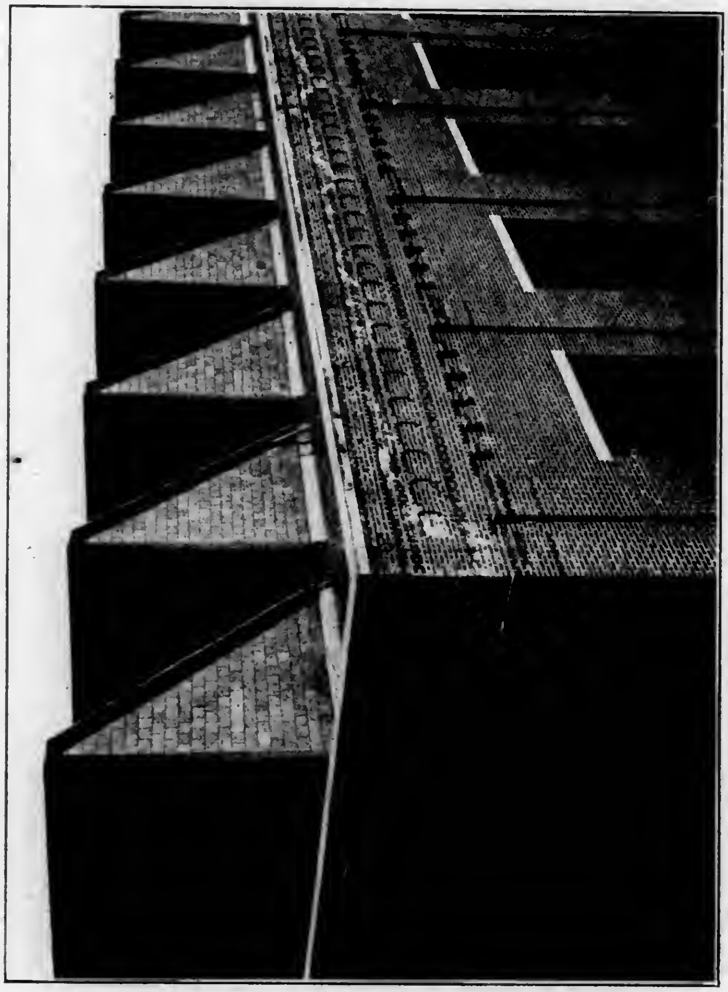
SOUTH END OF THE FREIGHT CAR REPAIR SHOP.



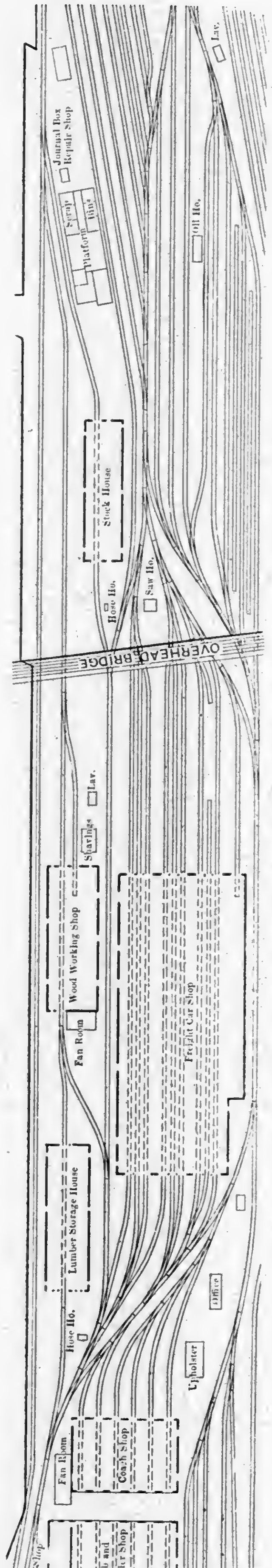
STORAGE SPACE FOR STEEL CAR REPAIR PARTS.



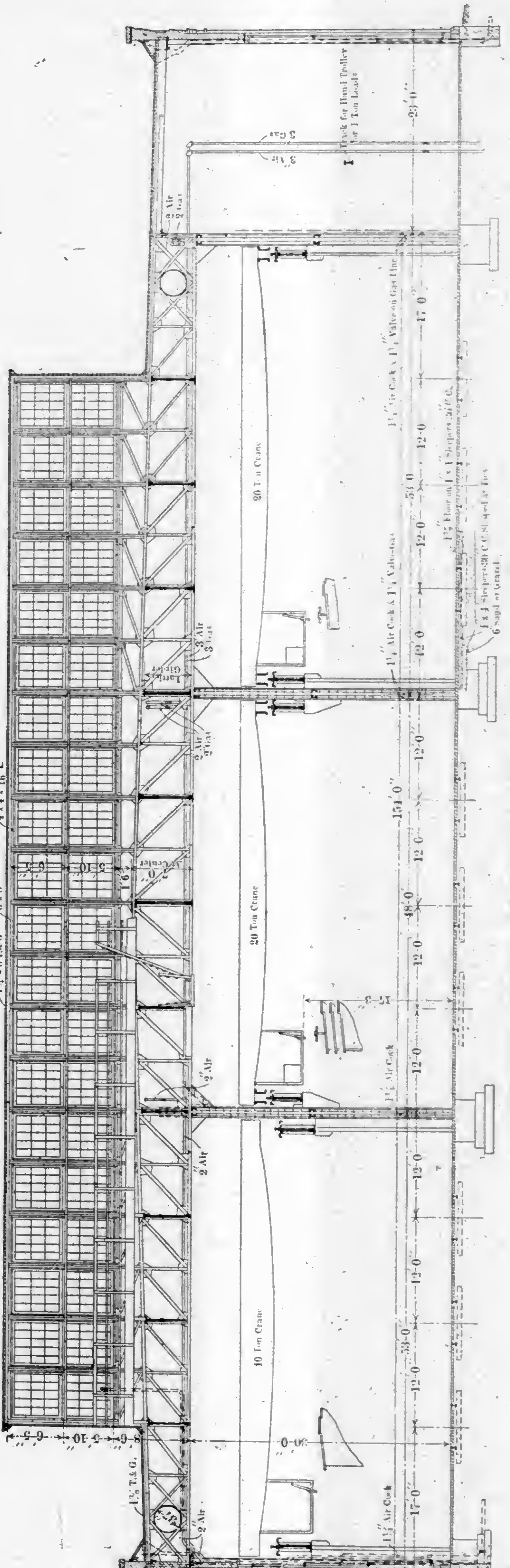
LOOKING DOWN THE MIDDLE BAY OF THE FREIGHT CAR REPAIR SHOP.



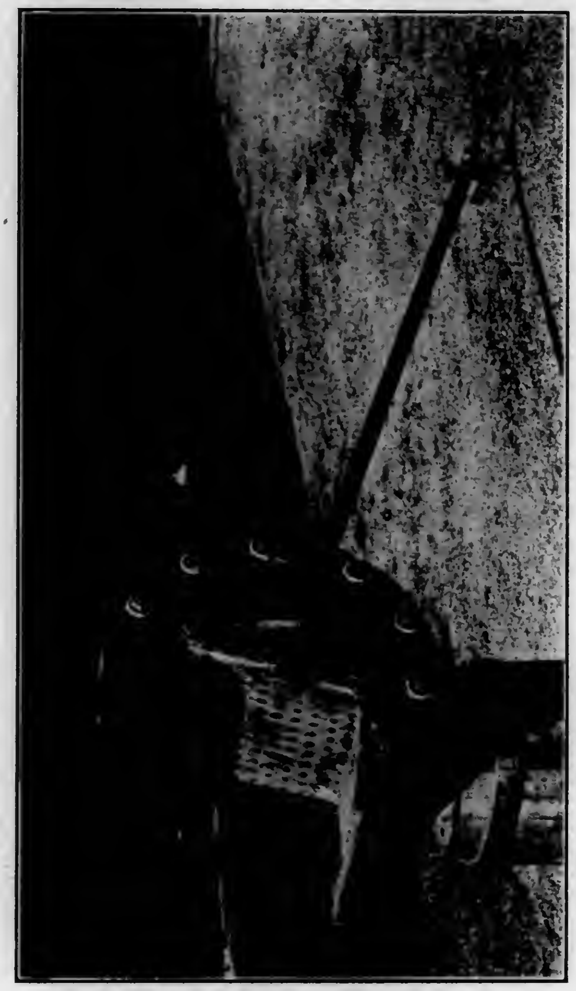
ROOF CONSTRUCTION OF THE FREIGHT CAR REPAIR SHOP.



GENERAL PLAN OF THE PITTSBURGH & LAKE ERIE RAILROAD CAR REPAIR DEPARTMENT, MCKEES ROCKS, PA.



CROSS-SECTION THROUGH THE FREIGHT CAR REPAIR SHOP AT MCKEES ROCKS, PA.

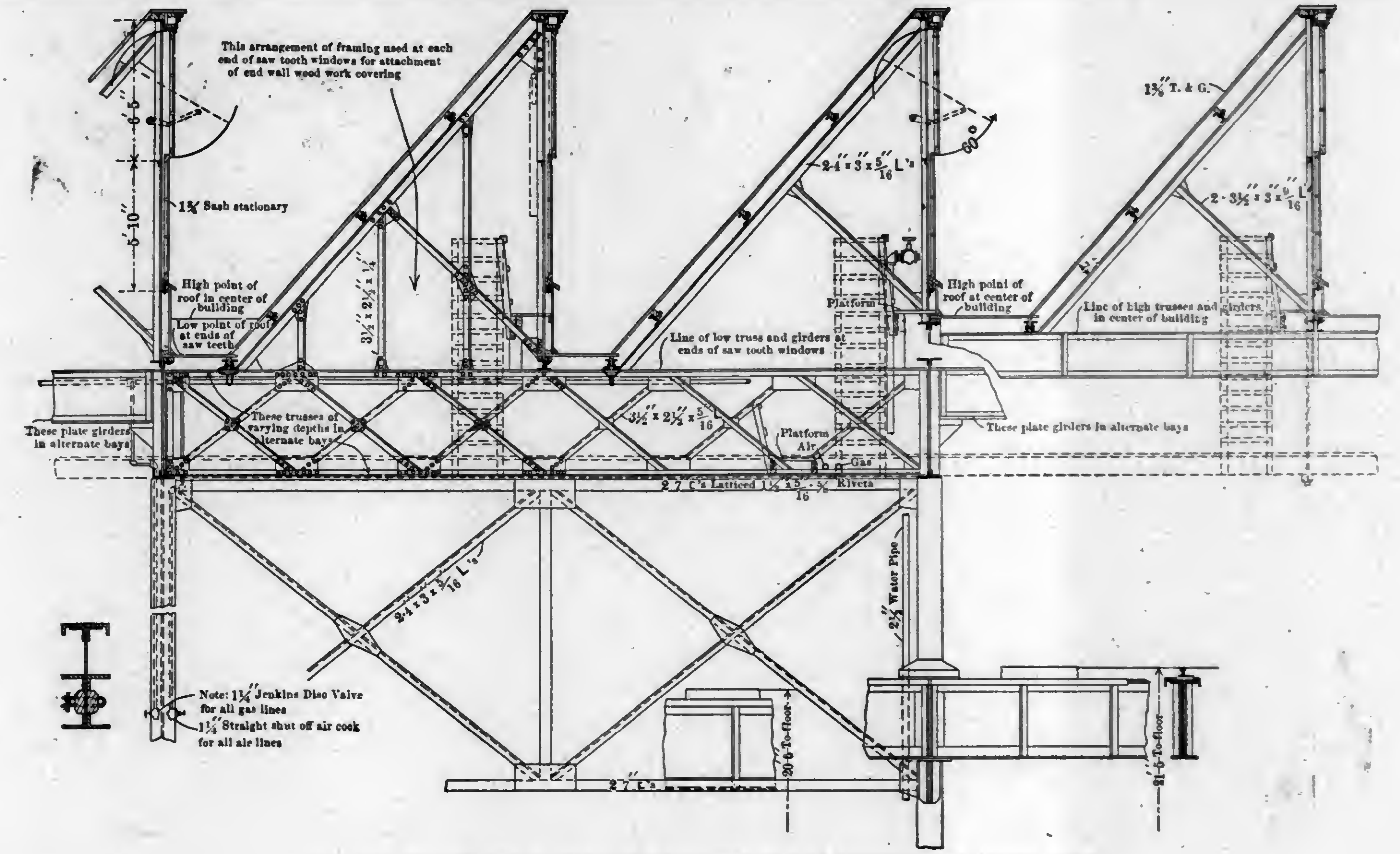


DEVICE FOR HEATING DAMAGED PARTS IN PLACE.

STEEL CAR REPAIR JACK.

PORTABLE RIVET HEATER.

FURNACE FOR HEATING DAMAGED PARTS.

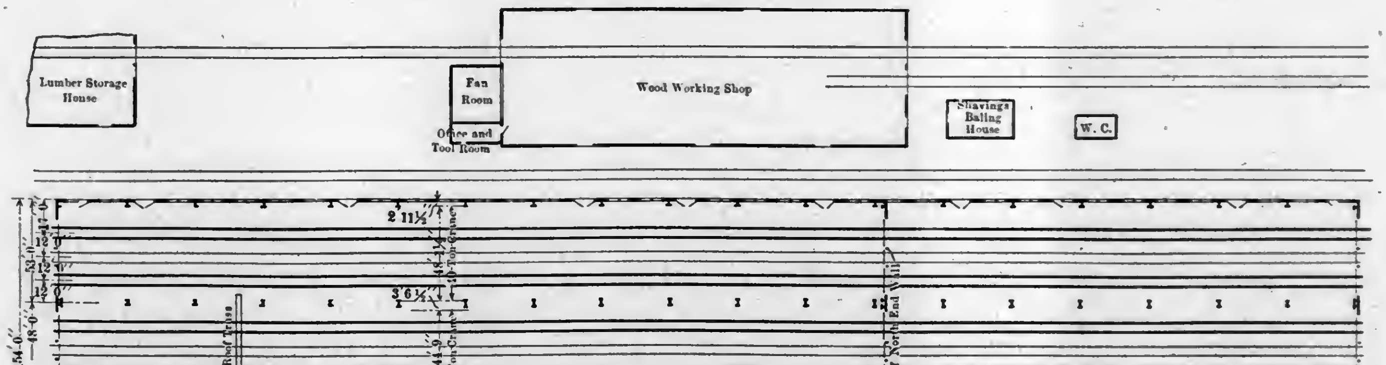


DETAILS OF SAW-TOOTH ROOF CONSTRUCTION OF THE FREIGHT CAR REPAIR SHOP.

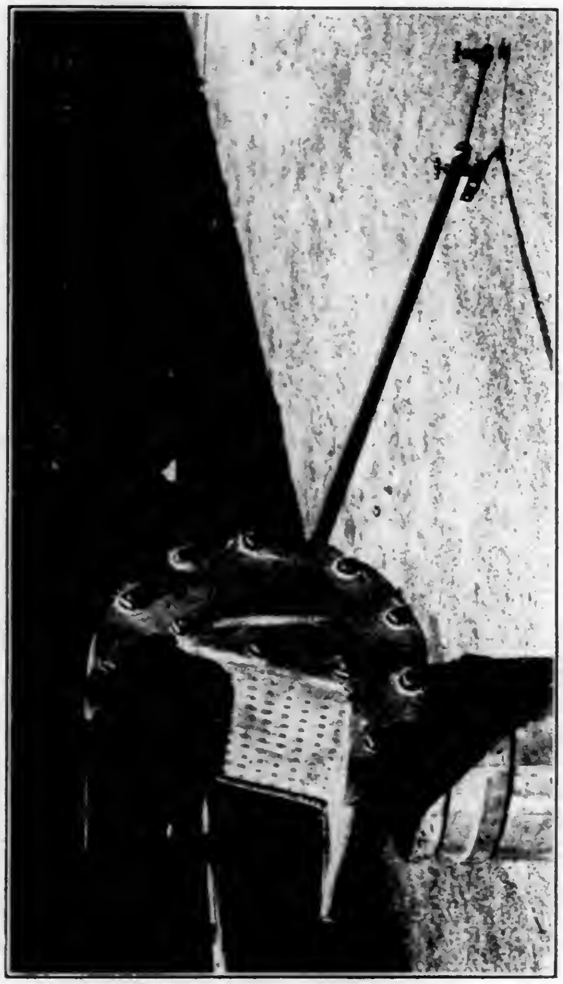
ated riveter for assembling the different parts, such as riveting the draft lugs to the draft sills, etc. A combination triple punching and shearing machine is to be added, capable of punching and shearing flat, angle and round iron. Beyond this is quite a large storage space for new parts and at the end of this portion of the shop a pipe fitting room, equipped with a rack, benches and pipe bending apparatus, is partitioned off. Extending over the middle of the extension or bay is a 10-in. I-beam track upon which two Yale & Towne duplex ½-ton hoists operate. These are used in connection with the handling of repair work and of the heavier pieces of material in the storage space.

It is possible to straighten many parts which are damaged without removing them from the car. These are heated in place by the burner illustrated, which uses natural gas mixed with air, the proper proportion being obtained by regulating the two valves. The device is very simple, consisting of a boiler plate box with a number of small holes, about 1/16 in. diameter in it, as shown. Three coke furnaces are used for heating rivets and are looked after by the rivet boys. Each furnace supplies rivets for four gangs. For work outside of the shop the portable forge, which is illustrated, is used. It is 16 in. in diameter, 12 in. deep and burns coke. The ash chamber, in which the air is also admitted, is about 7 x 7 x 6 in. deep.

The steel car jack, located as shown on the plan view of the shop, and shown in detail in the accompanying drawings and photographs, is a unique device and has been used with very satisfactory results for straightening the bodies of cars which have been badly twisted or distorted. It consists of a steel frame, anchored in concrete, fitted with a number of movable jacks. If the car body, or any portion of it, is badly damaged, or twisted, it is moved under this framework and with the aid of blocking in connection with the movable jacks it can usually be forced back



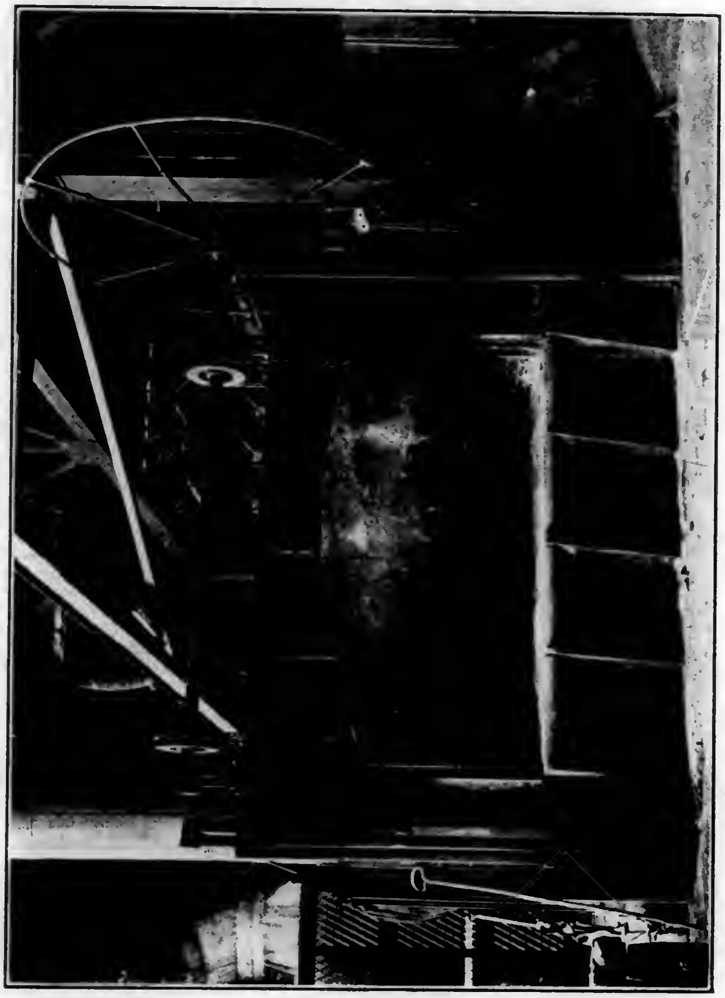
PLAN VIEW OF FREIGHT CAR REPAIR SHOP.



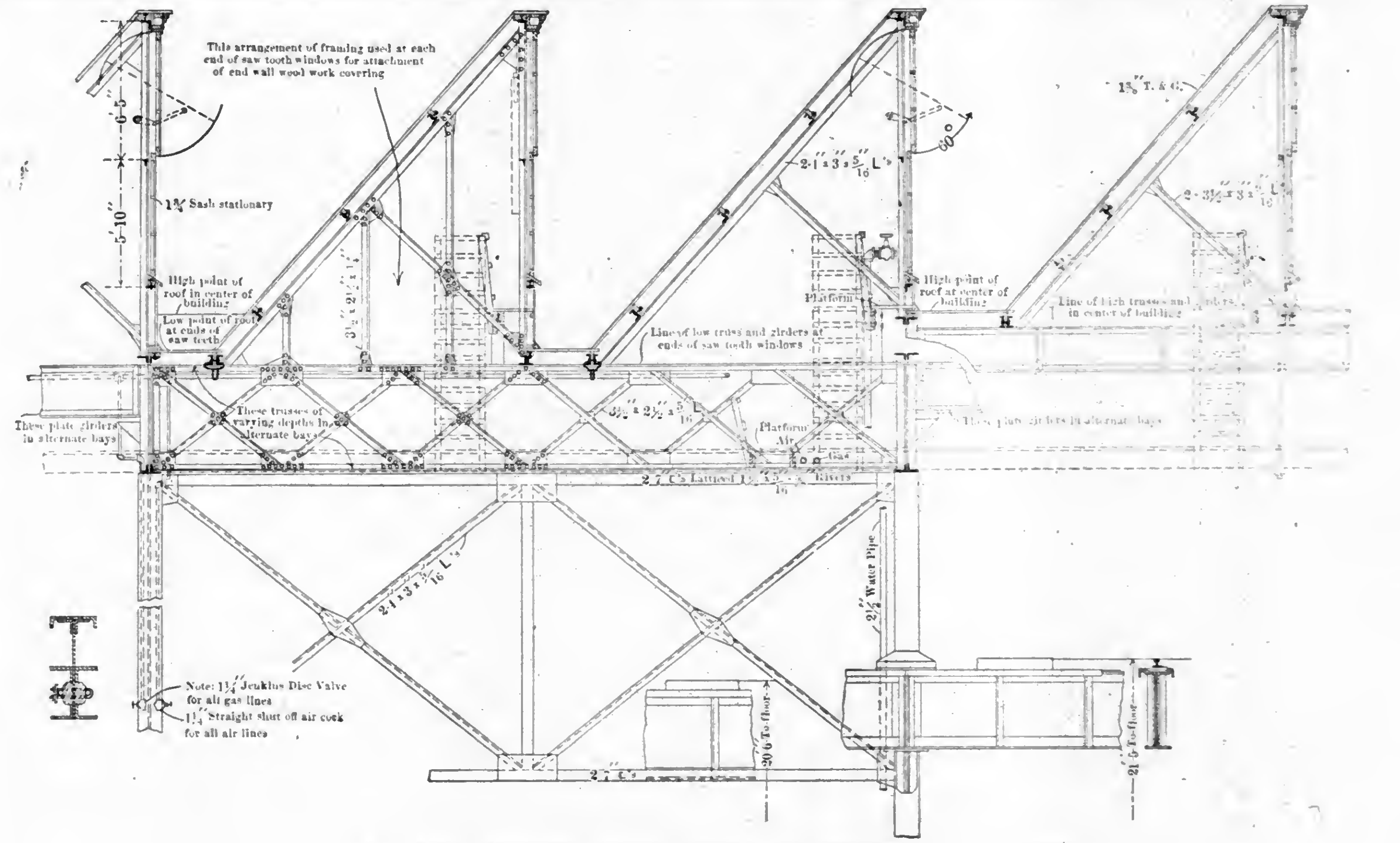
DEVICE FOR HEATING DAMAGED PARTS IN PLACE.

STEEL CAR REPAIR JACK.

PORTABLE RIVET HEATER.



FURNACE FOR HEATING DAMAGED **PARTS.**

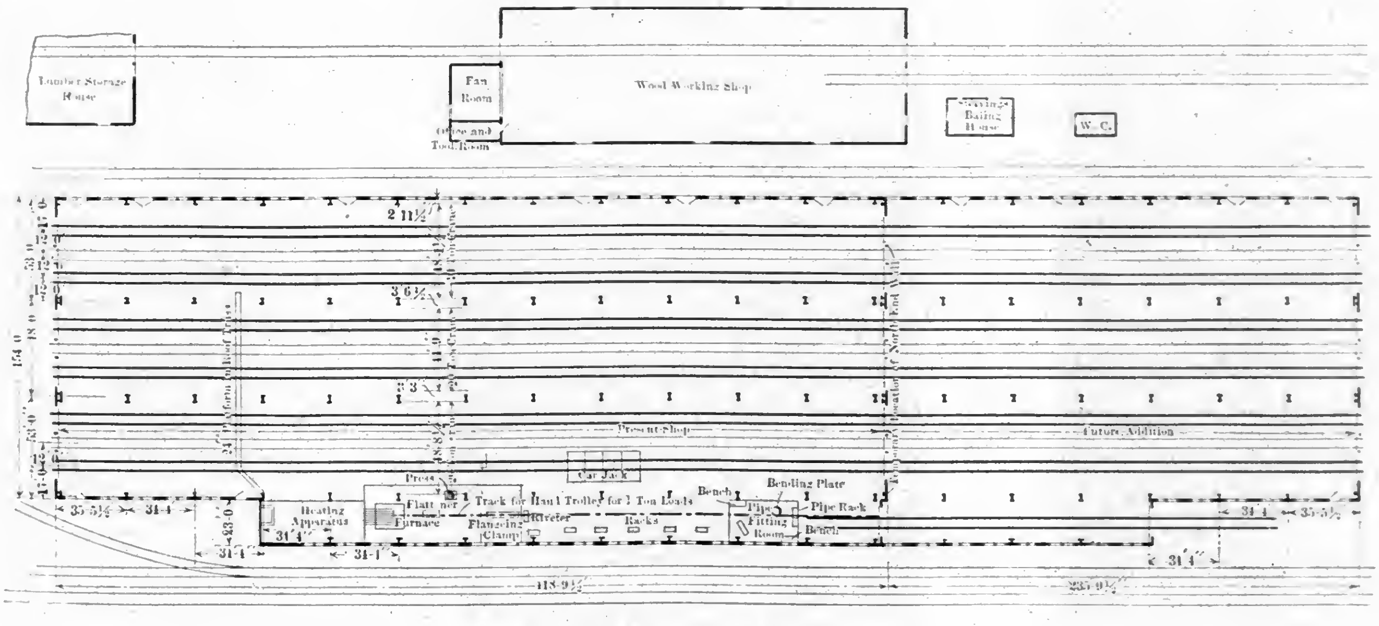


DETAILS OF SAW-TOOTH ROOF CONSTRUCTION OF THE FREIGHT CAR REPAIR SHOP.

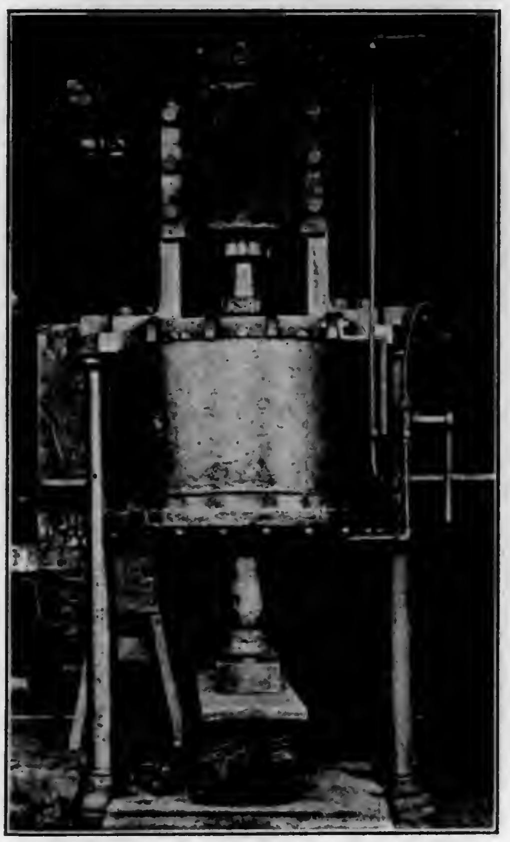
ated riveter for assembling the different parts, such as riveting the draft lugs to the draft sills, etc. A combination triple punching and shearing machine is to be added, capable of punching and shearing flat, angle and round iron. Beyond this is quite a large storage space for new parts and at the end of this portion of the shop a pipe fitting room, equipped with a rack, benches and pipe bending apparatus, is partitioned off. Extending over the middle of the extension or bay is a 10-in. I-beam track upon which two Yale & Towne duplex ½-ton hoists operate. These are used in connection with the handling of repair work and of the heavier pieces of material in the storage space.

It is possible to straighten many parts which are damaged without removing them from the car. These are heated in place by the burner illustrated, which uses natural gas mixed with air, the proper proportion being obtained by regulating the two valves. The device is very simple, consisting of a boiler plate box with a number of small holes, about 1/16 in. diameter in it, as shown. Three coke furnaces are used for heating rivets and are looked after by the rivet boys. Each furnace supplies rivets for four gangs. For work outside of the shop the portable forge, which is illustrated, is used. It is 16 in. in diameter, 12 in. deep and burns coke. The ash chamber, in which the air is also admitted, is about 7 x 7 x 6 in. deep.

The steel car jack, located as shown on the plan view of the shop, and shown in detail in the accompanying drawings and photographs, is a unique device and has been used with very satisfactory results for straightening the bodies of cars which have been badly twisted or distorted. It consists of a steel frame, anchored in concrete, fitted with a number of movable jacks. If the car body, or any portion of it, is badly damaged, or twisted, it is moved under this framework and with the aid of blocking in connection with the movable jacks it can usually be forced back



PLAN VIEW OF FREIGHT CAR REPAIR SHOP.



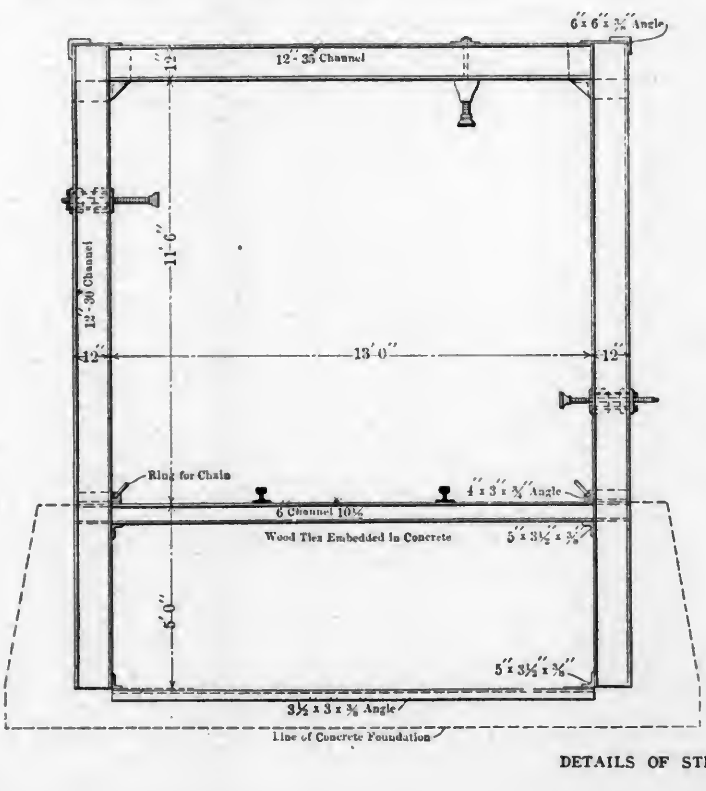
SMALL AIR PRESS.

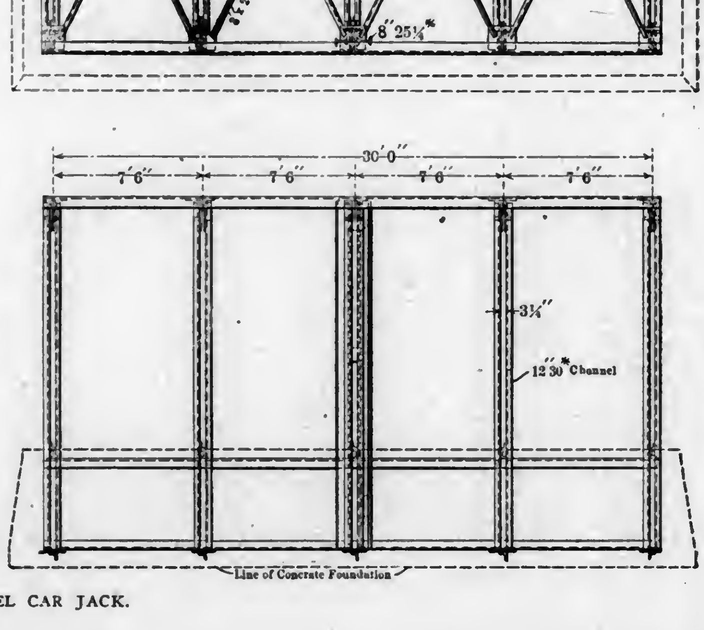
AIR OPERATED FLANGING CLAMP.

into shape with very little difficulty. The bodies are held securely in place by chaining them to the connections which are fastened to the lower part of the posts and anchored in the concrete. The saving of several hundred hours of labor has been possible in a number of instances, due to the use of this device.

The steel car force is divided into gangs of two men, each gang taking care of all of the repair work upon the car to which it is assigned, except the air brake work and the packing of journal boxes, which are looked after by special men. All of the work is done on a piece work basis. It is possible to use gangs of only two men to advantage because all of the heavy lifting is done by the traveling cranes. The three cranes are looked after by two operators, as the work can be so arranged that it is never necessary to have all three of them at work at the same time. In general the cars enter at the north end of the shop and when finished are taken out at the south end. If a car is finished ahead of those in front of it, it can easily be swung over on the material track, by the traveling crane, and moved out over that track. At the present time about 150 heavy steel car repairs are being made per month.

It has been found advisable to repaint the cars at intervals of about four years, when possible. They are painted with the New York Central Lines standard color. The paint is applied with spraying machines, which have been developed by Mr. W. O. Quest, the foreman painter. These machines have been used for a number of years and careful investigation has shown that the paint can be more evenly applied by the sprayer and penetrates much better than when applied with a brush. The operation of the spraying machine does not require highly skilled labor. The





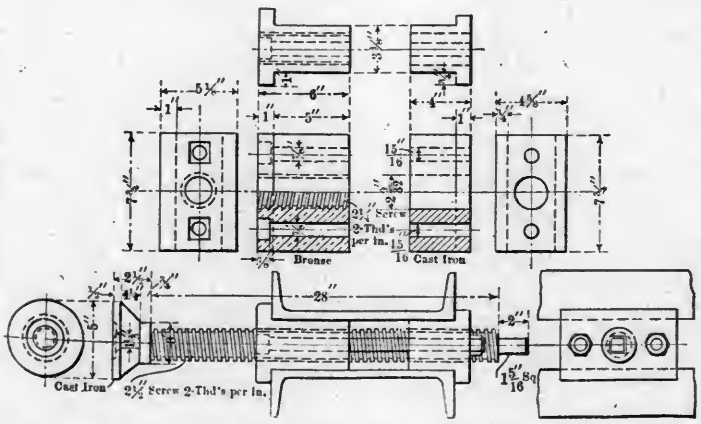
DETAILS OF STEEL CAR JACK.

writer watched a car painter who had had no previous experience in painting, and who had just been employed, and was painting his first car. It required five minutes to spray one side of the car and in 20 minutes he had completed the first coat on the car body satisfactorily. It is possible to apply the paint four or five times as fast with a sprayer as with a brush and at least ten per cent. less paint is required. The cars are thoroughly cleaned with wire brushes and scrapers before being painted and

AIR OPERATED RIVETER.

each car is given two coats of paint. The spraying machine is also used for painting the trucks. The insides of the cars are not painted. A number of experiments have been made with different materials, with the idea of protecting the inside of the car from corrosion, but the friction of the lading has in each case destroyed the covering in a very short time. Experiments are at present being made with crude oil which promises to be more successful.

The steel car repair department is in charge of a foreman who reports to the general foreman of car shops, Mr. H. W. Ferree,



SCREW JACKS USED WITH STEEL CAR JACKS.—FOR METHOD OF APPLYING SEE OPPOSITE PAGE.

who reports to Mr. G. E. Carson, master car builder. We are indebted to Mr. L. H. Turner, superintendent of motive power, to Mr. W. P. Richardson, mechanical engineer, and to the above named gentlemen for information and drawings.

HANDLING LOCOMOTIVE SUPPLIES.

By E. Fish Ensie.

This article will present the main features and some considerations in connection with the practical care, upkeep, supervision, and economy in the handling of engine equipments, based on an intimate experience of several years in this field of work, and covering the practice of a number of roads.

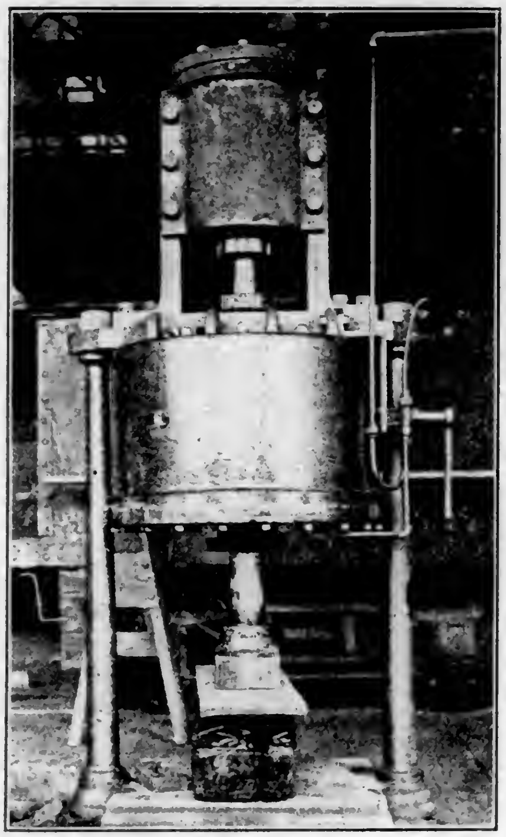
In general throughout the United States the expenditures for these supplies represent so small a portion of the operating costs, and are scattered over so wide an extent, that where railway officials and their staffs can find opportunity to divert their attention from questions pertaining to the immediate getting of the traffic over the road, they concern themselves with larger and more profitable problems. For the most part, therefore, there is no systematic supervision, accounting, or care for engine supplies. Some division officers will take an interest and better conditions for a time; others will let this minor item of expense go in the press of bigger matters; occasionally a general officer, such as a general manager or a superintendent of motive power, will attempt systematic regulation with the hope of some good general results, well worth while, even if the gleanings in particular localities are small; in such cases beneficial results may be temporarily secured. But the roads that are steadily achieving good practice in this respect in this country can be counted on the fingers of one hand. Even on casual observation it will become evident to those who are curious enough to get at the main facts, that there are large and unnecessary wastes of these supplies, and that as a consequence the average cost of this item of conducting transportation expense is four or five times what it should be.

This statement is no exaggeration. There are some roads where the total results are not so bad; there are others where they are much worse; the proportion named is a fair average of what obtains over the entire country, and is taken from the official records and accounts of the railways employing over half the locomotives in the United States.

There is spent annually in the United States between $4,000,000 and $5,000,000 for locomotive supplies alone, and nearly an additional million for labor in connection with the maintenance of this equipment. The cost of upkeep per locomotive per year will thus be seen to average above one hundred dollars, an altogether excessive figure. The full value of the equipment on an ordinary locomotive will vary from an average of $40 on some roads, to about $100 on others; the theoretical value of the equipment that is supposed to be on each engine will, as a rule, be somewhere between these limits. However, on some roads, and on some divisions of almost all roads, equipments will be incomplete; and in other instances there will be large overages. On an average each locomotive in the United States (and I emphasize the country, since they do things differently abroad, where they have a keener eye for detail, because they are not so swamped with traffic and must extract their earnings out of small savings and economies) will be completely re-supplied with its tool and supply equipment, as far as value is concerned, twice over each year.

Some articles, such as brooms, scoops, headlight chimneys, flags, fusees, torpedoes, and a very few others, actually require replacement oftener than this, but these articles are among the very least in value, and the more expensive items, such as re-railing frogs, jacks, blizzard lamps, screw pipe wrenches, etc., should last many years without renewal.

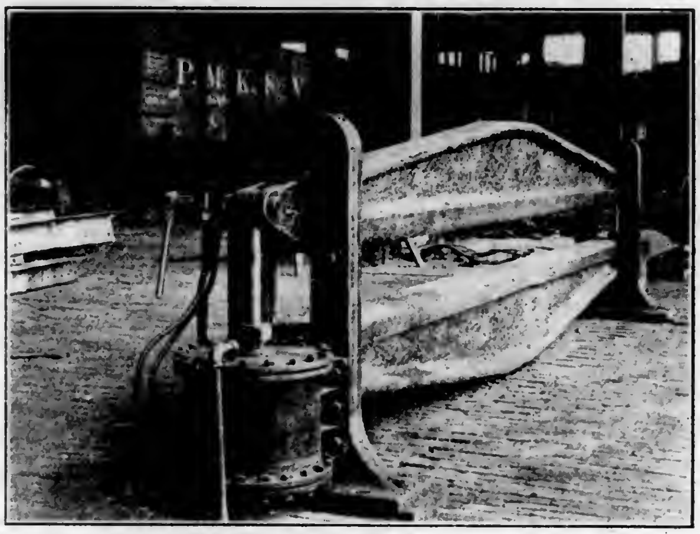
I have never seen what could be considered a minimum attained cost in this respect on any American railway, but from such thoroughly good and creditable performance as has been kept up month after month on particular divisions of certain roads, where the possibility of one division's enginemen stealing from another was carefully guarded against and effectually prevented; a fair figure for a reasonable attainment can be had. This figure is from 70c. to $1.50 per month for the cost of the supplies themselves, according to the quantity of the equipment carried on the engine and the geographical location of the division (west-



SMALL AIR PRESS.

into shape with very little difficulty. The bodies are held securely in place by chaining them to the connections which are fastened to the lower part of the posts and anchored in the concrete. The saving of several hundred hours of labor has been possible in a number of instances, due to the use of this device.

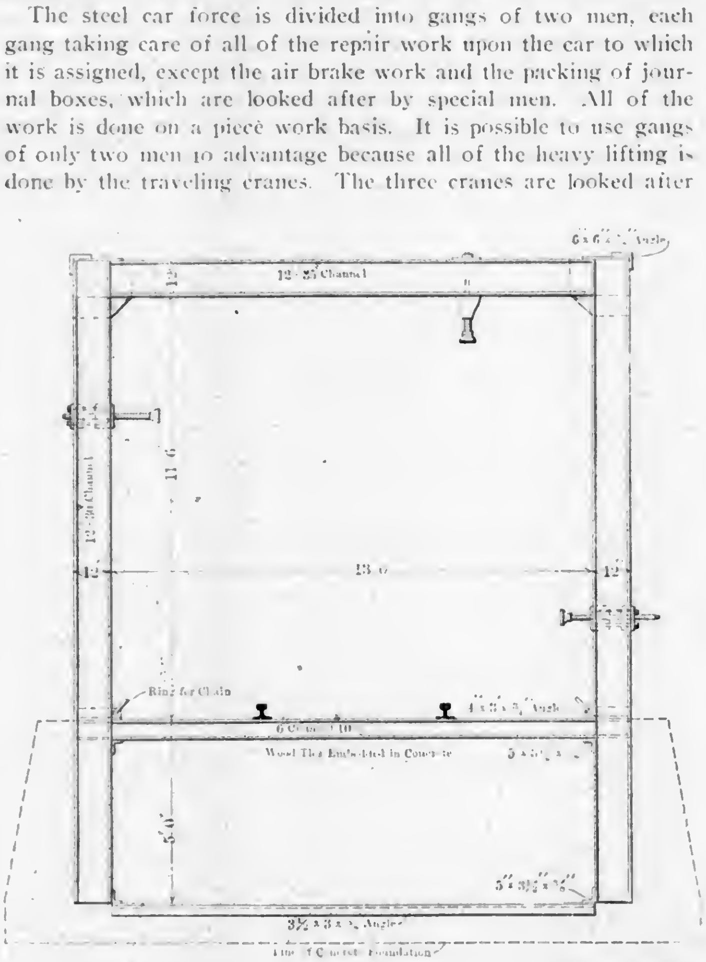
The steel car force is divided into gangs of two men, each gang taking care of all of the repair work upon the car to which it is assigned, except the air brake work and the packing of journal boxes, which are looked after by special men. All of the work is done on a piece work basis. It is possible to use gangs of only two men to advantage because all of the heavy lifting is done by the traveling cranes. The three cranes are looked after

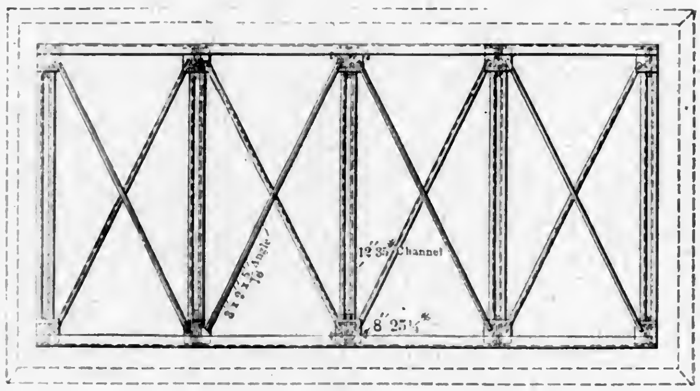


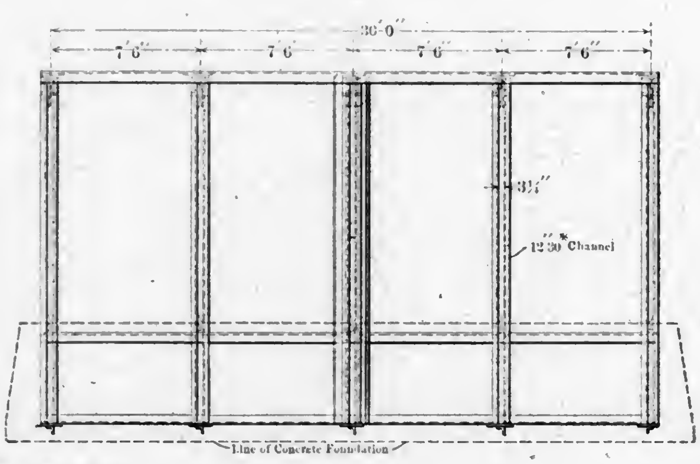
AIR OPERATED FLANGING CLAMP.

by two operators, as the work can be so arranged that it is never necessary to have all three of them at work at the same time. In general the cars enter at the north end of the shop and when finished are taken out at the south end. If a car is finished ahead of those in front of it, it can easily be swung over on the material track, by the traveling crane, and moved out over that track. At the present time about 150 heavy steel car repairs are being made per month.

It has been found advisable to repaint the cars at intervals of about four years, when possible. They are painted with the New York Central Lines standard color. The paint is applied with spraying machines, which have been developed by Mr. W. O. Quest, the foreman painter. These machines have been used for a number of years and careful investigation has shown that the paint can be more evenly applied by the sprayer and penetrates much better than when applied with a brush. The operation of the spraying machine does not require highly skilled labor. The







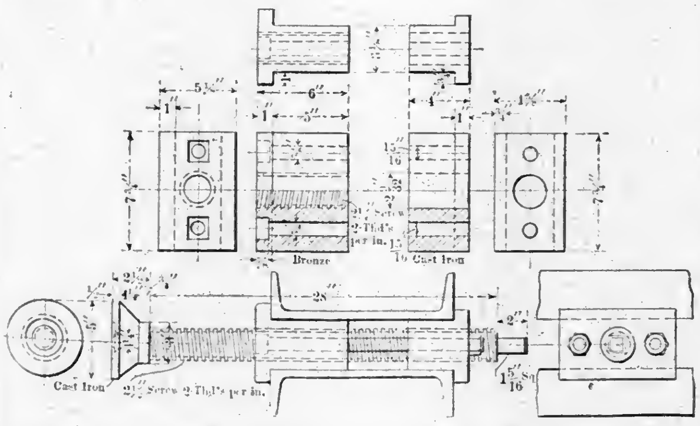
DETAILS OF STEEL CAR JACK.

writer watched a car painter who had had no previous experience in painting, and who had just been employed, and was painting his first car. It required five minutes to spray one side of the car and in 20 minutes he had completed the first coat on the car body satisfactorily. It is possible to apply the paint four or five times as fast with a sprayer as with a brush and at least ten per cent. less paint is required. The cars are thoroughly cleaned with wire brushes and scrapers before being painted and

AIR OPERATED RIVETER.

each car is given two coats of paint. The spraying machine is also used for painting the trucks. The insides of the cars are not painted. A number of experiments have been made with different materials, with the idea of protecting the inside of the car from corrosion, but the friction of the lading has in each case destroyed the covering in a very short time. Experiments are at present being made with crude oil which promises to be more successful.

The steel car repair department is in charge of a foreman who reports to the general foreman of car shops, Mr. H. W. Ferree,



SCREW JACKS USED WITH STEEL CAR JACKS.—FOR METHOD OF APPLYING SEE OPPOSITE PAGE.

who reports to Mr. G. E. Carson, master car builder. We are indebted to Mr. L. H. Turner, superintendent of motive power, to Mr. W. P. Richardson, mechanical engineer, and to the above named gentlemen for information and drawings.

HANDLING LOCOMOTIVE SUPPLIES.

By E. Fish Ensie.

This article will present the main features and some considerations in connection with the practical care, upkeep, supervision, and economy in the handling of engine equipments, based on an intimate experience of several years in this field of work, and covering the practice of a number of roads.

In general throughout the United States the expenditures for these supplies represent so small a portion of the operating costs, and are scattered over so wide an extent, that where railway officials and their staffs can find opportunity to divert their attention from questions pertaining to the immediate getting of the traffic over the road, they concern themselves with larger and more profitable problems. For the most part, therefore, there is no systematic supervision, accounting, or care for engine supplies. Some division officers will take an interest and better conditions for a time; others will let this minor item of expense go in the press of bigger matters; occasionally a general officer, such as a general manager or a superintendent of motive power, will attempt systematic regulation with the hope of some good general results, well worth while, even if the gleanings in particular localities are small; in such cases beneficial results may be temporarily secured. But the roads that are steadily achieving good practice in this respect in this country can be counted on the fingers of one hand. Even on casual observation it will become evident to those who are curious enough to get at the main facts, that there are large and unnecessary wastes of these supplies, and that as a consequence the average cost of this item of conducting transportation expense is four or five times what it should be.

This statement is no exaggeration. There are some roads where the total results are not so bad; there are others where they are much worse; the proportion named is a fair average of what obtains over the entire country, and is taken from the official records and accounts of the railways employing over half the locomotives in the United States.

There is spent annually in the United States between $4,000,000 and $5,000,000 for locomotive supplies alone, and nearly an additional million for labor in connection with the maintenance of this equipment. The cost of upkeep per locomotive per year will thus be seen to average above one hundred dollars, an altogether excessive figure. The full value of the equipment on an ordinary locomotive will vary from an average of $40 on some roads, to about $100 on others; the theoretical value of the equipment that is supposed to be on each engine will, as a rule, be somewhere between these limits. However, on some roads, and on some divisions of almost all roads, equipments will be incomplete; and in other instances there will be large overages. On an average each locomotive in the United States (and I emphasize the country, since they do things differently abroad, where they have a keener eye for detail, because they are not so swamped with traffic and must extract their earnings out of small savings and economies) will be completely re-supplied with its tool and supply equipment, as far as value is concerned, twice over each year.

Some articles, such as brooms, scoops, headlight chimneys, flags, fusees, torpedoes, and a very few others, actually require replacement oftener than this, but these articles are among the very least in value, and the more expensive items, such as re-railing frogs, jacks, blizzard lamps, screw pipe wrenches, etc., should last many years without renewal.

I have never seen what could be considered a minimum attained cost in this respect on any American railway, but from such thoroughly good and creditable performance as has been kept up month after month on particular divisions of certain roads, where the possibility of one division's enginemen stealing from another was carefully guarded against and effectually prevented, a fair figure for a reasonable attainment can be had. This figure is from 70c. to $1.50 per month for the cost of the supplies themselves, according to the quantity of the equipment carried on the engine and the geographical location of the division (west-

ern expenses being higher), and an additional sum of 75c. to $1 for all supervisory, clerical, and labor expense, or a total of between $1.50 and $2.50 per month per engine in actual service. Of course, much lower figures have been, and can be attained; some engineers, where the pooled system of engine assignment is not in effect, after being provided with an equipment, manage to hold on to it, and get good service from it, for years with a trifling upkeep cost of a few cents per month. However, it would be no argument to condemn the handling of engines in pool, because it made the cost of engine supplies rather higher; that would be surely looking through the wrong end of the spy-glass. A figure, covering the total of all costs relative to engine equipments, in the neighborhood of $2 per month, or $25 per year is amply generous, and will enable the company giving the proper attention to this matter, to provide the very best of equipment, the very finest and most durable of oil cans, torches, water glasses, tools, etc.; to have at all times a complete equipment in perfect condition on every engine in service, and to have them carefully and systematically looked after and checked up.

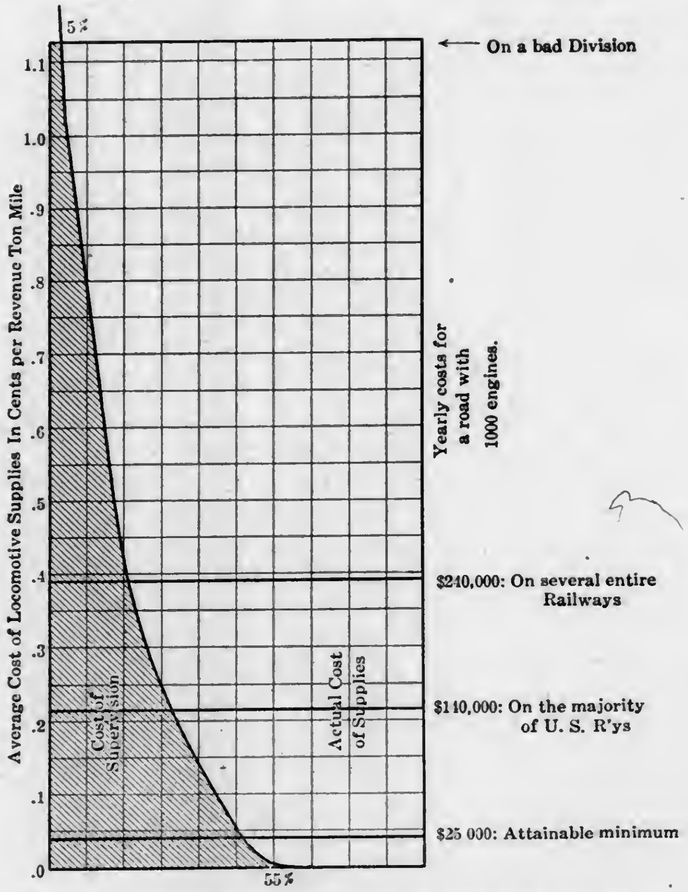


FIG. 1.—ACTUALLY OBSERVED COSTS OF HANDLING ENGINE EQUIPMENTS.

How many roads in the country have reached this condition of affairs? Yet the most of them pay four or five times the price of this practically perfect service, and get a wretched result; they pay this sum for the supplies alone, and an additional amount for labor to look after the supplies (perhaps), labor that is assigned other duties, and is underpaid, hence inefficient.

A good supplyman in the east will cost from 18c. to 22c. an hour; west of the Mississippi the rate will range from 25c. to over 50c., according to the conditions and the man. Supplymen, or equippers, or tool checkers (they are variously designated, and have varying functions) rarely get such rates of pay, and as a consequence at division points and storehouses, where the railway company might by spending $10 to $20 per month in higher wages to such a man, securing reasonable economy in these supplies, they lose from $50 to *over* $500 per month, at each of these points by getting along with poorly paid, inefficient, and wasteful help.

Of course, the mere question of wages to these men is not going to solve all the difficulties and automatically secure proper economy and care of these equipments. There must be at the same time an intelligent selection of these men, a certain training, and a comprehensive scheme, with traveling inspectors, so as to bring about a general uplift and uniform improvement in all respects.

Equipment should be redesigned in many cases; the list of articles supposed to go on each engine should probably be revised and a number which in modern times have no further usefulness, eliminated. The accounting should be thoroughly gone into, and a thorough system for checking results and costs in detail, and placing individual responsibility, put into effect. All these things will cost effort, and brains, and trouble; they will cost a certain amount of money; *they will pay for themselves many times over, and within two or three months' time, if properly pushed. It is entirely feasible to make these improvements pay for themselves out of the second month's reduction in wasteful expenditure.* I say two months, because it takes a certain amount of time to investigate accounts, to find out what is actually going on, and to secure the necessary approvals for amplification of the accounting system to give the figures that are needed for close and careful supervision, promptly, unerringly, and specifically. The geographical extent of the road will also have a bearing on the speed with which results can be secured, a widely extended road requiring more time than a dense, compact one; however, the long road will probably have much higher costs to begin with, so that larger results can be obtained.

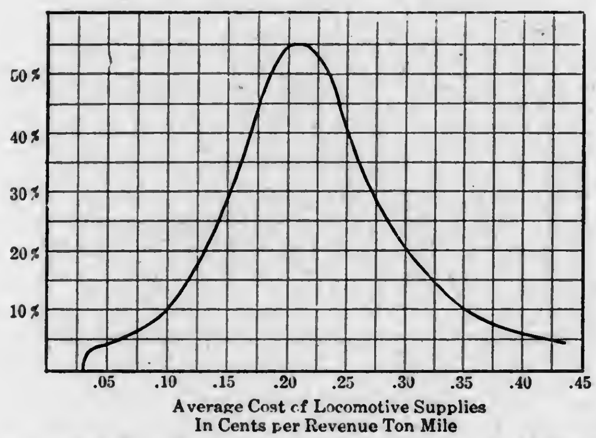


FIG. 2.—PROPORTION OF RAILWAYS HANDLING ENGINE EQUIPMENTS AT VARIOUS DEGREES OF COST.

Figure 1 represents in chart form the costs, in decimals of a cent per revenue net ton mile, of upkeep of engine equipments on three specific roads, and on one specific division of one of the roads. The basis of measure is taken in ton miles, although it is realized that there are certain disadvantages in connection with the use of this unit. A preferable figure, perhaps, would be the road unit adopted by the statistical departments of many railways, consisting of a ratio between the weight of locomotives on drivers, the engine miles, and the costs to be measured. But this figure is not always so readily ascertainable as it should be, and so the more familiar ton mile unit is here employed for illustration. The diagram also shows the costs in annual totals, and the proportion of supervision and labor in that cost at different degrees of efficiency. The most effective results seem to be secured where the supervisory cost equals, or slightly exceeds, the actual cost of the supplies used; that is, at that point there is the minimum total expenditure. As the supervision is relaxed, the waste of the supplies, and irregularities of all sorts, appear and grow. It should be explained also, in connection with this diagram, that the yearly costs represent the expenditure of a road having 1,000 locomotives.

Figure 2 is another diagram showing what proportion of the railways of the United States fall under each degree of expensiveness in this small item of maintenance. Thus over 50 per cent. of the railways pay more than .2c. per ton mile; less than 10 per cent. pay as little as .1c. and another 10 per cent. pay

about .35c. These figures are in tenths and hundredths of a cent—not in whole cents. The diagram is only approximately correct as the figures for all roads are not available; but it is sufficiently representative of the large majority of them to be trustworthy in the main. I doubt if any portion of the curve will be found to be more than 4 per cent. in error. This is not close, but it is close enough for the purpose intended.

The general aspects of this question have been presented; they may be recapitulated:

Engine equipments are very necessary, and sometimes must serve in cases of great need; their value at that time far exceeds their cost.

In order to have them available at all times, they must be kept up in good condition, must be checked over, and shortages guarded against. Rusty jacks are useless; a wrecking frog that was left last week near the scene of a freight car derailment and subsequent replacement (of the car—not the frog), is of no avail; long oilers with leaky spouts are expensive and wasteful; scoops, too, have a way of mysteriously disappearing in roundhouses—really there is no mystery at all. All these little defects of lack of systematic care must be remedied if good service is to be given, and that is the first desideratum.

Because of waste, this item of expenditure is now excessive on almost every railroad in the country.

Improved service costs nothing; it is paid for out of economies early effected; the cost is merely a case of accounting.

Mere increase in wages will not secure the best results, or perhaps any results at all. Yet a first class and well trained man, with perhaps as much jurisdiction in his field as a general boiler inspector has in his, and with probably the same pay as the usual general boiler inspector gets, is not too high to go. Such a man, if properly selected and thoroughly qualified for his task, will accomplish much more, and that more speedily, than a cheaper, less experienced man. And right here let us admit that the usual general boiler inspector is not paid nearly enough for the importance of his duties, nor does he have the authority he should have. If the position were made more attractive, the very best men could be secured, and what that would pay in boiler care!

The more thoroughly the problem is worked out and studied from the very start, and the more progressively it is pushed, the larger will be the ultimate gains and the sooner will large gains be apparent.

By the pursuit of proper methods any road should reduce its costs in this respect to a maximum of one-half mill per net revenue ton mile; any general manager or other interested party can tell how much can be added to the net earnings of his road by this standard; the annual economies will foot up from $10,000 to over $200,000 according to the size of the road; if groups of roads be taken, the totals will be larger still. Such accounts, although small compared with other expenditures, are yet well worth the picking in these hard times when retrenchment is in order.

If the items of locomotive oil and waste, and of caboose equipments also fall under the same jurisdiction, the gross amounts dealt with are more than trebled, and the effectable reductions also correspondingly increased, although perhaps not in equal measure. And these other items admit of being easily and naturally handled in conjunction with the engine supplies. The proportionate supervisory force does not have to be so large. On a system of about the size of the Pennsylvania and its controlled lines, a net expense reduction of nearly a million dollars should be quite possible, in these accounts alone.

Having summarized the aims, and results to be secured, we can proceed to a discussion of the detail methods involved.

Accounts.—These are now provided for under numbers 78, 81, 82, 87, 90, 91, and 95, more particularly, as indexed on page 19 of the Third Revised Issue of the Classification of Operating Expenses, as prescribed by the the Interstate Commerce Commission. It will be found desirable, and in fact necessary, to subdivide these accounts, and to re-group them for purposes of supervision and information. For instance, pay of tool checkers, a roundhouse expense, should be separated from other items of roundhouse expense, and should, in the summaries, be added to the totals of the costs of supplies furnished to locomotives, so that the proportion between supervision and material may be ascertained and the amount of the net reduction be determined.

Matters will be greatly simplified if there is but one set of fundamental records, upon which all later figures, and arrangements of figures, are based. Only in this way can consistency in the accounts, and a proper balance, be secured. These fundamental records should be:

Abstracts from the payrolls and expense vouchers, covering the pay and expenses of all labor and supervisory talent used in connection with this plan.

Duplicates of all orders placed for the purchase of equipment, showing where orders originated and the necessity therefor. Advice should be given of the cancellation and of the delivery of each order cancelled or filled.

Regular and frequent statements should be made showing material available in each storehouse.

Duplicates of each requisition made on stores for each article should be furnished; it is recommended that a special requisition blank for these supplies be adopted, or the regular form specially designated in some way.

These requisitions should indicate:

The article drawn.
The date.
The account chargeable.
The engine or purpose for which drawn.
The man drawing it.
The man filling it.
The man or men (in the case of an engine, the engineer and fireman) for whose use intended.
Whether the article is new or second hand.
Whether the old article was returned when the new was drawn; if not, an explanation, on proper form, of why needed.
The place or store where drawn.

From these fundamental records will be compiled recapitulations and summaries, by articles, by places, by engineers, by firemen, by engines; averages over divisions can be shown of costs per engine per month, or per engine mile, or ton mile, or other convenient unit, for material (or any article), and for labor and supervision. By means of such records, which are neither difficult nor expensive to keep, the excessive costs can be located, investigated, and corrected. Costs will melt away like snows under a summer sun; costs cannot remain excessive and salient under high illumination and burning scrutiny.

And the recapitulations should reconcile very closely with the statements compiled and approved by the auditors; all records, so far as practicable, should be prepared by members of the accounting staff, and their time, if of any considerable proportion, separately apportioned so as to be charged against the cost of effecting the reductions.

Filling Requisitions.—Requisitions for the purchase or acquirement of new equipment material should be checked by the man in charge of this work; useless expense may thus be nipped in the bud, and a control may be had over the selection of the material, which should always be in conformity with the adopted standards of design and specification.

Requisitions on local storehouses should, wherever practicable, be handled entirely by the man locally in charge of supplies and equipments at each place. This man should be responsible for seeing that engines are properly provided for, and the practice of enginemen running to storehouse and filling their own requisitions should not be tolerated where it can at all be avoided.

Standardizing Equipment.—All equipment should be reduced to uniform standards and specifications, and drawings made of each article. Articles may then be ordered by number, without error. If practicable, the items of the equipment that are similar to those used in the shops and roundhouses, such as hammers, chisels, etc., should be of distinctive design, so that if they are appropriated by shopmen they can be detected. The engineer's hammer might have a wedge pein, for instance, while the shopmen generally use a ball pein; the engineer's chisel might be of hexagon steel.

Not only should all the tools be thus standardized, but the tool boxes should be similarly standardized, and their location upon engine and tender likewise definitely determined. Moreover, the tools and articles that are to go into each box should be foreordained, and the boxes so designed that everything may have its place. Those boxes that need them should be provided with locks, preferably master-keyed in some way; locks, hinges, hasps and boxes should be, as far as possible, protected from being broken into by substantial design. In ascertaining standards, the best articles that can be found for their purpose should be secured and tested out, and, if successful, adopted.

All this standardization, which is an important factor in the larger ultimate permanent economies, need not be a source of alarm to the railroad management; a draughtman's services may be required for as much as a month, in order to get out the drawings and designs. But the substitution of the standardized material for the old material on hand and in use will be a gradual process. Old equipment will be kept in use until worn out, unless markedly defective; the older equipment might be retired to the branch line runs, or those engineers who showed a tendency to take care of their equipments might be rewarded by being given new sets on their engines, relegating the older

material to the careless men. Standardization is rather a provision for the future than a move for immediate gain.

Checking Equipment.—Perpetual inventory of all equipment at all times should be kept. The man in charge should know:

What articles are needed, and where and why.

When they will be got, and at what expense.

Stock on hand at each store.

Equipment located on each locomotive (different classes of service will have different requirements; an engine with electric headlight will have to carry spare carbons, for instance, and perhaps a few lamp parts).

Each article that passes out of service; each replacement that takes place, and why.

To insure the engine inventory being kept up, to put the local supply man or equipper in a position to know the needs of each equipment, so he can fill them, there should be periodical and frequent inspection of equipments, preferably every trip at the principal division points. The equipper or inspector, with his master-key, is able to tell almost at a glance whether everything is in its place in the standard boxes and make out a complete report on a form for the purpose. This inspection will average from 3 to 6 minutes per engine. (See Figure 3, standardized box, facilitating inspection.)

If engines are inspected, both going out and coming in, there is an absolute check against the engineer. Everyone should be provided with the proper and regular equipment all the time, so there is no excuse for pilfering from each other. Such cases are very hard to catch, but when caught should be very severely dealt with. Tools may be marked with the engine number, but this is often a very inconvenient procedure.

Caring for Equipment.—Engines going to shop, unless in charge of a messenger, who would be checked up like an engineer, should have all equipment removed and either placed in a special box and sent along, or kept at the home division point. If the equipment is marked it should go with the engine, otherwise it may be put at once into service, where it can earn the money invested in it, and other equipment may be placed upon the engine when it comes out of the shop. If the records and accounts are properly kept, there need be no injustice done either to an engine or to an engineer in his record by this plan.

When articles are damaged they should be taken out of service and replaced by sound articles. The old ones will be accumulated and repaired, either by sending to the central shops (a rather slow process, of more trouble than economy except in the case of the heavier tools, such as switch chains, jacks, and blizzard lamps), repaired in the local shop, or even tinkered up by the equipper if he has the time and the knack. Figure 4 shows a box car which serves as such a den for an equipper, an ex-engineer; Figs. 5 and 6 are interiors of this car. Fig. 7 is another such equipper's storehouse and repair shop.

The equipper makes it his duty to go about shop yards and pick up scrap and old material and see that it is put in shape. This material is used up instead of drawing new supplies. Large savings are secured in this way. Storehouses whose issues were running $1,200 to $1,500 per month, find that their issues drop to $300 or $400, on averages extending over many months, when this policy is resorted to; issues averaging $650 drop to less than $200. If the old equipment is properly cleaned, and put in good shape, there can be no valid objection to its use by the men.

Figures 7, 8, 9, 10 and 11 illustrate valuable equipment that was picked up in this way during two months at one place, besides what was issued from this old stock. This was put in shape, and the pictures show the surplus. These pictures represent material of the value of over $400. Such savings, when systematically pursued and directed over an entire railway sys-

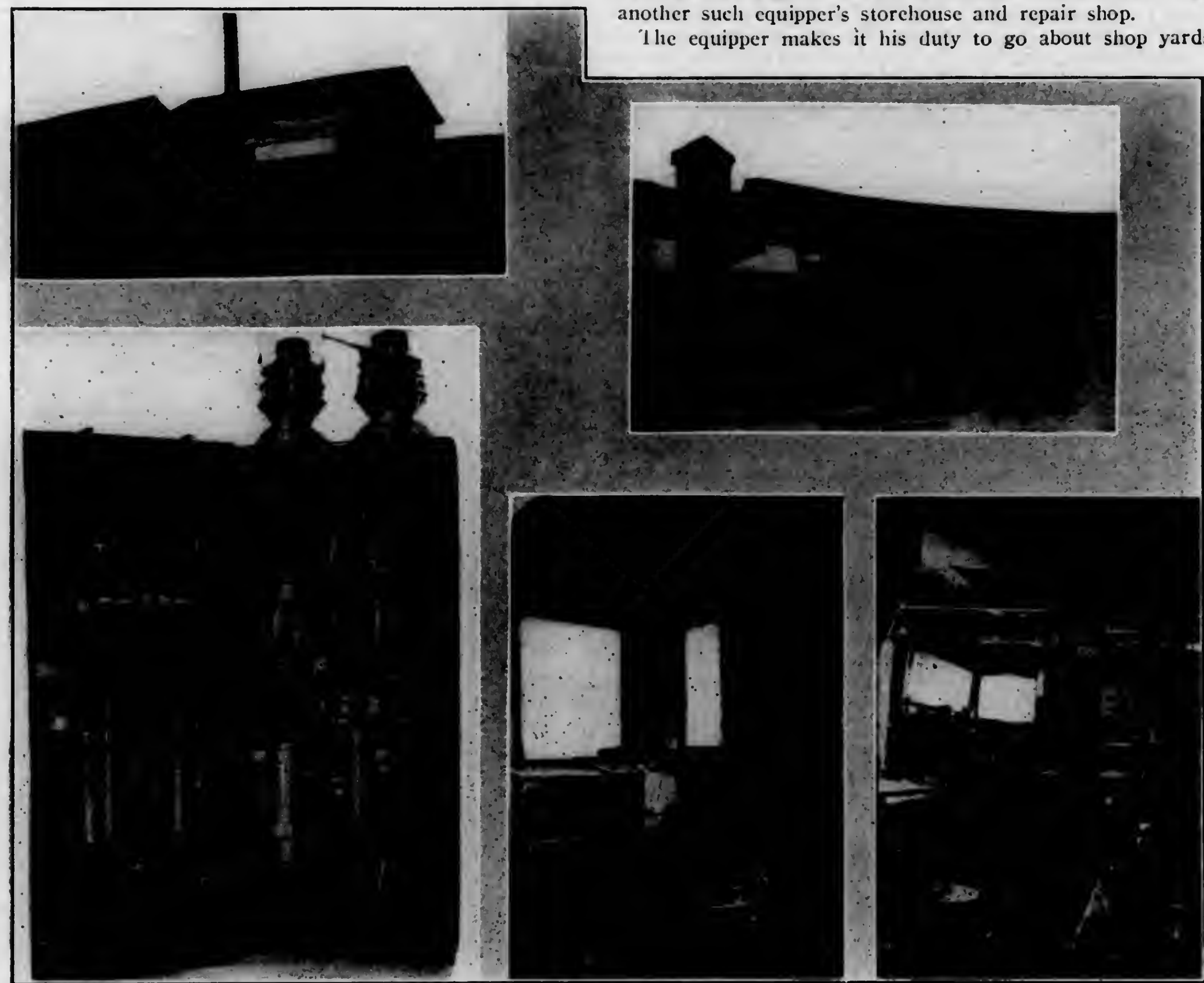
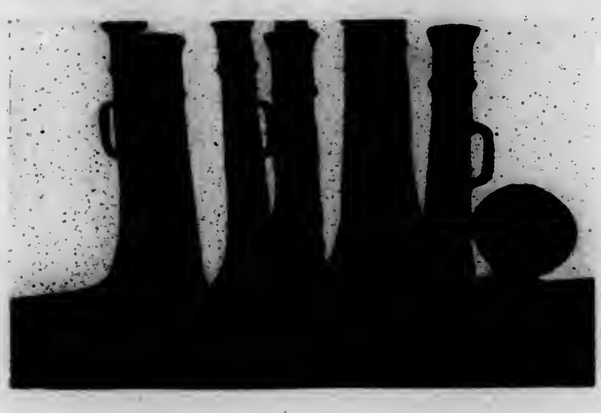


FIG. 7.—SUPPLYMAN'S STOREHOUSE AND REPAIR SHOP.
FIG. 3.—STANDARD TOOL BOX.

FIG. 4.—OLD BOX CAR EQUIPPED FOR SUPPLYMAN.
FIGS. 5 AND 6.—INTERIOR OF BOX CAR. FIG. 5.—DESK. FIG. 6.—OFFICE AND GAUGE TESTING MACHINE.



FIGS. 7, 8, 9, 10 AND 11.
VALUABLE EQUIPMENT PICKED FROM SCRAP, REPAIRED AND PUT BACK INTO SERVICE.

tem, roll up handsome aggregates, and always look well in the decrease column of the expense account in the annual report to the stockholders at the end of the year. And if the company shows that it has an interest in thrift, the example will be a good one on its employees.

Below is a statement of one month's repair work, done by the supplyman, or which he had done at the local shop, on old and otherwise useless equipment:

Class of Repairs.	Number repaired.	Material charges.	Labor charges.	Average cost.
Grinding chisels	93	$0.00	$0.60	$0.01
Applying hammer handles	55	1.65	.60	.04
" pick "	6	.75	.10	.14
Overhauling 12" screw-wrench	12		1.57	.13
" 15" "	33		3.27	.10
" 18" "	3		.67	.22
Soldering engineers' oilers	22		1.30	.06
" tallow pots	22		.97	.04
" two gal. oil cans	9		.65	.07
Repairing water glass lamps	10		.32	.03
" tin torches	7		.65	.09
" marker lamps	21		3.91	.19
" 24" screw jacks	1		.22	.22
" 18" " "	2		.44	.22
" No. 8 Norton jacks	3		.65	.21
" 6" screw jacks	6		1.34	.22
Straightening pinch bars	12		.50	.04
Cutting off coal scoops	39		.80	.02
Total		$2.40	$18.50	
Grand total			$20.90	

In this particular case over $200 worth of material was saved and used, the cost of repairs being but $20.

Conclusion.—One might go much further, if space permitted, and give in detail the exact accounting forms used, the number of men necessary in each capacity on a road, of say, 1,000 engines, etc.; in other words a complete sketch of all the items of cost in connection with the establishment of such an equipment supervision system might be given, both with respect to amounts, and various departments of the work, as well as with reference to the progress of the work, and its probable extra (if any) cost from month to month, together with results secured month by month.

It is sufficient to say that by the end of the first year after work in this direction has been commenced, a reduction of expense, coincident with much constructive improvement in service, of at least 20 per cent. net should be expected; in the second year the results should be still better, and the reductions more than double this figure; in the third year the full measure of efficiency and economy should be attained, and thereafter kept up.

It is suggested, in view of the limited experience in this direction, that inducements for economy on the part of the supplymen be held out in the way of definitely promised (and substantial) increases in rate of pay, provided certain results are achieved; that the co-operation of enginemen may be obtained by periodically giving prizes in cash, or in other valuable consideration, such as a specially fine personal kit of tools, or card transportation privileges, these rewards to be for conspicuous care of tools, etc.

To sum up: While not a dollar should be invested in a new tool when an old one will do just as well, or nearly as well; while only such labor and brains should be employed as are actually seen to bring about economies, more than paying for the supervisory cost, etc.; and while the rates of pay should be increased only as a direct result of economies effected; it is advisable to keep in sight the fact that the important thing for the interest of the railway is to—*First: Keep the equipment up in the very best of shape. Second: Reduce the total of all expenses in connection with handling it, even though this does proportionately or absolutely increase the labor and supervision cost.* And if the job is worth tackling at all, it is worth tackling well and thoroughly, so as to get full, and not half results. Give the man you place in charge your backing, and he will pay you for it well, if he is the right sort. If feasible, extend his duties to cover the caboose equipments, and the oil supplies furnished engines; this will result in greater economy in handling, as well as in larger net results at the year's end.

material to the careless men. Standardization is rather a provision for the future than a move for immediate gain.

Checking Equipment. Perpetual inventory of all equipment at all times should be kept. The man in charge should know:

What articles are needed, and where and why.

When they will be got, and at what expense.

Stock on hand at each store.

Equipment located on each locomotive (different classes of service will have different requirements; an engine with electric headlight will have to carry spare carbons, for instance, and perhaps a few lamp parts).

Each article that passes out of service, each replacement that takes place, and why.

To insure the engine inventory being kept up, to put the local supply man or equipper in a position to know the needs of each equipment, so he can fill them, there should be periodical and frequent inspection of equipments, preferably every trip at the principal division points. The equipper or inspector, with his master key, is able to tell almost at a glance whether everything is in its place in the standard boxes and make out a complete report on a form for the purpose. This inspection will average from 3 to 6 minutes per engine. (See Figure 3, standardized box, facilitating inspection.)

If engines are inspected, both going out and coming in, there is an absolute check against the engineer. Everyone should be provided with the proper and regular equipment all the time, so there is no excuse for pilfering from each other. Such cases are very hard to catch, but when caught should be very severely dealt with. Tools may be marked with the engine number, but this is often a very inconvenient procedure.

Caring for Equipment. Engines going to shop, unless in charge of a messenger, who would be checked up like an engineer, should have all equipment removed and either placed in a special box and sent along, or kept at the home division point. If the equipment is marked it should go with the engine, otherwise it may be put at once into service, where it can earn the money invested in it, and other equipment may be placed upon the engine when it comes out of the shop. If the records and accounts are properly kept, there need be no injustice done either to an engine or to an engineer in his record by this plan.

When articles are damaged they should be taken out of service and replaced by sound articles. The old ones will be accumulated and repaired, either by sending to the central shops (a rather slow process, of more trouble than economy except in the case of the heavier tools, such as switch chains, jacks, and blizzard lamps), repaired in the local shop, or even tinkered up by the equipper if he has the time and the knack. Figure 4 shows a box car which serves as such a den for an equipper, an ex-engineer; Figs. 5 and 6 are interiors of this car. Fig. 7 is another such equipper's storehouse and repair shop.

The equipper makes it his duty to go about shop yards and pick up scrap and old material and see that it is put in shape. This material is used up instead of drawing new supplies. Large savings are secured in this way. Storehouses whose issues were running $1,200 to $1,500 per month, find that their issues drop to $700 or $900, on averages extending over many months, when this policy is resorted to; issues averaging $650 drop to less than $200. If the old equipment is properly cleaned, and put in good shape, there can be no valid objection to its use by the men.

Figures 7, 8, 9, 10 and 11 illustrate valuable equipment that was picked up in this way during two months at one place, besides what was issued from this old stock. This was put in shape, and the pictures show the surplus. These pictures represent material of the value of over $100. Such savings, when systematically pursued and directed over an entire railway sys-

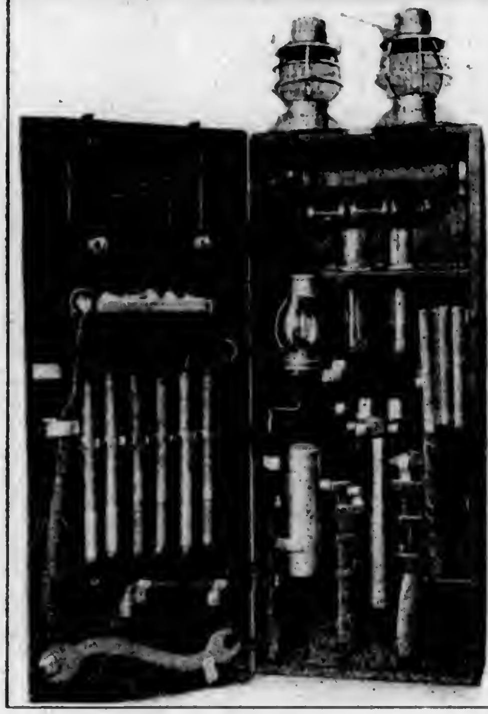


FIG. 7.—SUPPLYMAN'S STOREHOUSE AND REPAIR SHOP.
FIG. 3.—STANDARD TOOL BOX.

FIG. 4.—OLD BOX CAR EQUIPPED FOR SUPPLYMAN.
FIGS. 5 AND 6.—INTERIOR OF BOX CAR. FIG. 5.—DESK. FIG. 6.—OFFICE AND GAUGE TESTING MACHINE.

FIGS. 7, 8, 9, 10 AND 11:
VALUABLE EQUIPMENT PICKED FROM SCRAP, REPAIRED AND PUT BACK INTO SERVICE.

tem, roll up handsome aggregates, and always look well in the decrease column of the expense account in the annual report to the stockholders at the end of the year. And if the company shows that it has an interest in thrift, the example will be a good one on its employees.

Below is a statement of one month's repair work, done by the supplyman, or which he had done at the local shop, on old and otherwise useless equipment:

Class of Repairs.	Number repaired.	Material charges.	Labor charges.	Average cost.
Grinding chisels	93	$0.60	$0.66	$0.01
Applying hammer handles	55	1.65	.60	.04
" pick "	6	.75	.10	.14
Overhauling 12" screw wrench	12		1.57	.13
" 15" "	33		3.25	.10
" 18" "	3		.67	.22
Soldering engineers' oilers	22		1.30	.06
" tallow pots	22		.97	.04
" two gal. oil cans	9		.65	.07
Repairing water glass lamps	10		.32	.03
" tin torches	7		.65	.09
" marker lamps	21		3.91	.19
" 24" screw jack	1		.22	.22
" 18" " "	2		.44	.22
" No. 8 Norton jacks	3		.65	.21
" 6" screw jacks	6		1.31	.22
Straightening pinch bars	12		.50	.04
Cutting off coal scoops	39		.80	.02
Total		$2.10	$18.80	
Grand total			$20.90	

In this particular case over $200 worth of material was saved and used, the cost of repairs being but $20.

Conclusion.—One might go much further, if space permitted, and give in detail the exact accounting forms used, the number of men necessary in each capacity on a road, of say, 1,000 engines, etc.; in other words a complete sketch of all the items of cost in connection with the establishment of such an equipment supervision system might be given, both with respect to amounts, and various departments of the work, as well as with reference to the progress of the work, and its probable extra (if any) cost from month to month, together with results secured month by month.

It is sufficient to say that by the end of the first year after work in this direction has been commenced, a reduction of expense, coincident with much constructive improvement in service, of at least 20 per cent. net should be expected; in the second year the results should be still better, and the reductions more than double this figure; in the third year the full measure of efficiency and economy should be attained, and thereafter kept up.

It is suggested, in view of the limited experience in this direction, that inducements for economy on the part of the supplymen be held out in the way of definitely promised (and substantial) increases in rate of pay, provided certain results are achieved; that the co-operation of enginemen may be obtained by periodically giving prizes in cash, or in other valuable consideration, such as a specially fine personal kit of tools, or card transportation privileges, these rewards to be for conspicuous care of tools, etc.

To sum up: While not a dollar should be invested in a new tool when an old one will do just as well, or nearly as well; while only such labor and brains should be employed as are actually seen to bring about economies, more than paying for the supervisory cost, etc.; and while the rates of pay should be increased only as a direct result of economies effected; it is advisable to keep in sight the fact that the important thing for the interest of the railway is to—*First: Keep the equipment up in the very best of shape. Second: Reduce the total of all expenses in connection with handling it, even though this does proportionately or absolutely increase the labor and supervision cost.* And if the job is worth tackling at all, it is worth tackling well and thoroughly, so as to get full, and not half results. Give the man you place in charge your backing, and he will pay you for it well, if he is the right sort. If feasible, extend his duties to cover the caboose equipments, and the oil supplies furnished engines; this will result in greater economy in handling, as well as in larger net results at the year's end.

STEEL PASSENGER EQUIPMENT.*

By Charles E. Barba and Marvin Singer.

THE UNDERFRAME.—PART II.

Synopsis.

Graphical Analysis.

Static Loading.—For purposes of illustration we have assumed a center sill loaded as indicated, *i. e.,* Form 2. The methods followed in this example are applicable to any class of lading whatsoever. The lading diagram (Fig. 11) needs explanation to make it easy to clearly follow the bending moment curves. There is a definite uniform center sill lading which will vary with the detail design of the flooring and the weight of seats used, and will include half the live load. Likewise there is a certain uniform side sill lading extending between body end sills which depends upon the cross section and the weight of seats and the live lading as shown in Fig. 8, for any special case.

The uniform side sill loads are transferred to the center sills as concentrated loads by the transverse side sill supports, namely P_1, P_3, and a portion of P_2. In determining the value of each of these concentrated loads it is assumed that each cantilever supports that portion of the side sill which extends on either side of it to a point midway between the successive cantilevers. The other portion of P_2 is one-half of the vestibule load which is transferred to the center sills through the body corner posts, the end door posts and the body end sills. This must be added to the portion of uniform side sill lading that the body end sill carries to the center sills to complete the local concentrated load at this point. There now remains for P_1 the remaining half of the vestibule weight. This vestibule weight should include all the fittings which are necessary to make the car complete, such as draft gear and attachments, buffers, trap doors, diaphragms, etc.

The bending moment diagrams are not drawn to any scale of foot or inch pounds, but show the general character of the curves that will be found from application to any definite car. It has been deemed advisable to show the separate effects of the overhanging and then of the central loads and following these, the combined diagrams, though the latter can easily be drawn at once by superimposing the separate curves in one figure.

Curve 7 illustrates the varying bending moments due to all the dead and live loads, both uniform and concentrated, upon the center sills. This curve is found by algebraically adding and subtracting the bending moment ordinates of curves 3 and 6. These curves are drawn by means of the customary polar diagrams of lading.

End Shocks.—There are several methods which can be used to combine the bending moments occasioned by the end shocks with the foregoing moments due to static lading.

The first step is the determination of the line of action of this force. The friction draft gears are capable of absorbing 150,000 pounds when the buffers become solid against the platform end sills. At this point in the yielding compression the draft gear is still capable of a small amount of movement before going solid, hence the remaining 350,000 pounds for a 500,000 pound end shock and 250,000 pounds for a 400,000 pound end shock must be taken by the end casting. Both of these are transferred to the center sills, the buffing shock at a point above the neutral axis and the pulling shocks ~~below~~, in the usual case, though it does not matter if this condition is not fulfilled so far as this presentation is concerned.

There is evidently a point through which the line of action of the sum total end shocks can be made to pass, so that the effects of this combined load on the center sills is the same as that for the two separate eccentric forces. Fig. 12 shows that if moments be taken about the resultant line R that the location of this line will be given by the relation G = 3/7 F, or, in other words, G is 3/10 the distance between the center line of the buffers and draft gear and F 7/10. This is for values of B = 350,000 and D = 150,000 pounds. For B equal to 250,000 and D equal to 150,000 pounds the relations as expressed above become G = 3/5 F, G = 3/8 and F = 5/8 distance between B and D.

This will enable the eccentricity H of end shock to be found since the distance from the neutral axis to B and D are known.

Fig. 13 illustrates the condition to be considered with a pulling load. The moment arm is much increased and is shown as J. It should be noted that the moment curve is below the neutral axis in this case. The fact that the deflection Y = △ at a maximum is noted the same in both figures does not imply their identity.

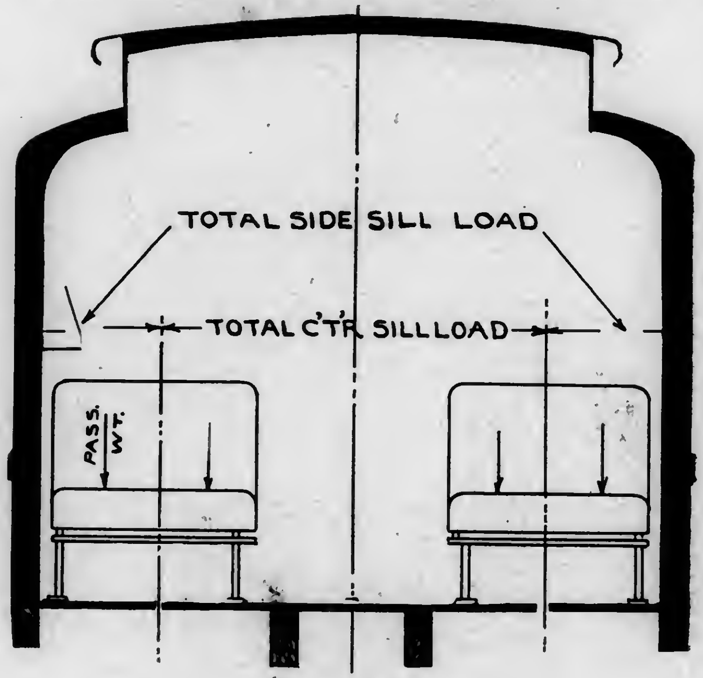


FIG. 8.

If at the end of the center sills and in the same vertical plane as the application of the end shock, two equal and opposite forces of the same magnitude as the end shock, be supposed to act it will be seen that the one—R (see Fig. 12) produces a direct compressive stress and that there remains a couple +R and R which produces a bending moment equal to Rh about the neutral axis. The same procedure will hold with the same effect in Fig. 13, except that here we have +D as a direct axial tensile strain and a moment DJ about the neutral axis.

The effects of this bending moment, which is a variable throughout the length of the beam, upon the various sections of the beam, are hard to properly take care of. The difficulty lies in securing an assumption for a basis of calculation which does not interpose prohibitive mathematical calculations. To assume that the arc of bending of the neutral axis is a portion of a circle is not true, for by solving the general equation of the elastic curve bent according to this supposition the deflection is found to be

$$\triangle = \frac{ML^2}{8EI} \text{ where}$$

M = bending moment.
L = length between supports in inches.

* Copyright, 1908, by Chas. E. Barba.

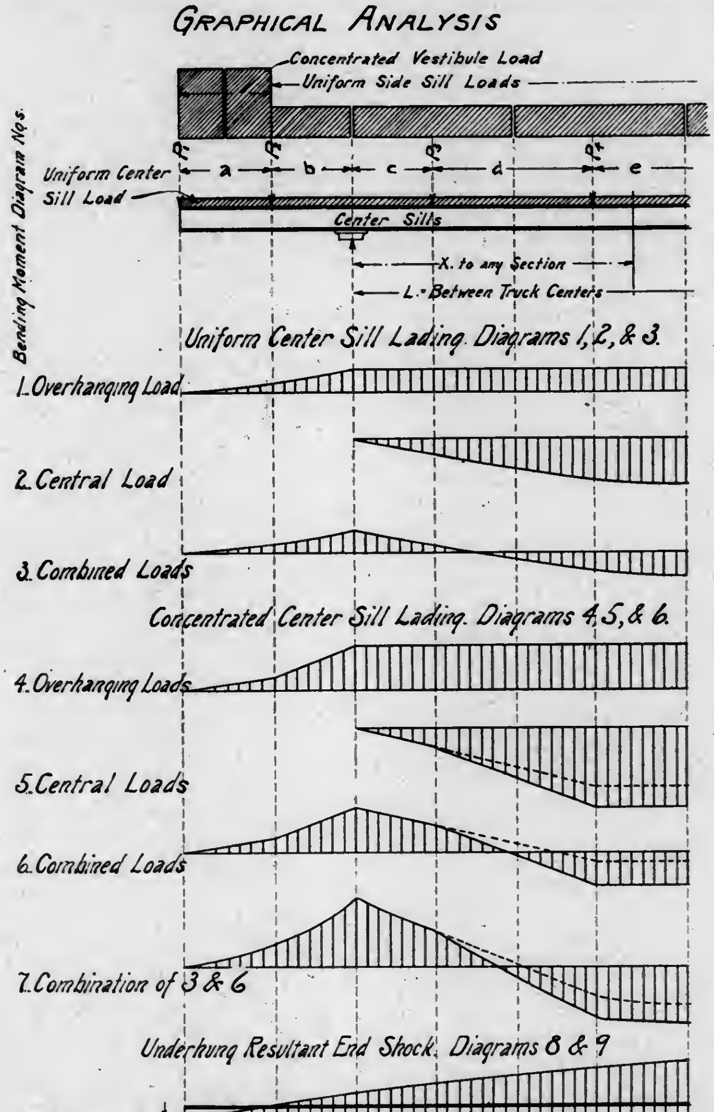


FIG. 11.

E = coeff. of elasticity.
I = moment of inertia.

In this there has been neglected $\triangle^2$, which is an infinitesimal in beams properly designed for stiffness. This value is but 80 per cent. of what it would be for the theoretical curve with a load concentric with neutral axis. This again does not take into account that, as a beam with an end load bends further from the neutral axis the farther the point of such bending be taken from the end, the bending moment is increased continually by this increase in deflection up to the point of maximum deflection. If the same general equation of the elastic curve $M = \frac{EI}{r}$, where r = radius of curvature, be solved with the bending moment arm considered as

$$H + \int_{x=0}^{x=\frac{L}{2}} Y dx$$

the resultant will take the form of a transcendental equation where

$$y = (\text{function}) \sin x + \text{constant}.$$

This introduces circular functions into the problem and the

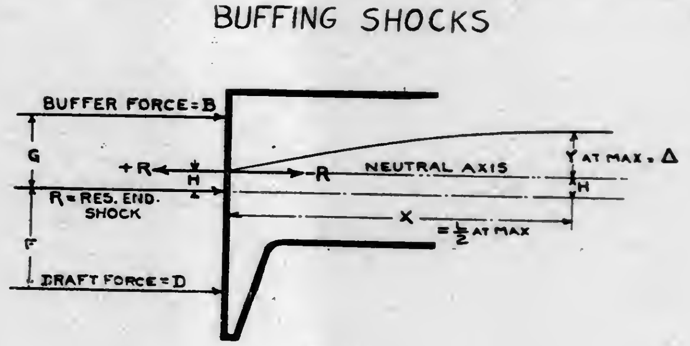


FIG. 12.

maximum deflection at the center can be shown to be

$$\triangle = \frac{RHL^2}{\pi^2 EI - RL^2} \text{ or } \frac{DJL^2}{\pi^2 EI - DL^2}$$

Hence at a maximum the arm of R. or D as the case may be, becomes

$$H + \frac{RHL^2}{\pi^2 EI - RL^2} \text{ or } J + \frac{DJL^2}{\pi^2 EI - DL^2}$$

and the bending moment is

$$R\left[H + \frac{RHL^2}{\pi^2 EI - RL^2}\right] \text{ or } D\left[J + \frac{DJL^2}{\pi^2 EI - DL^2}\right]$$

To draw the curve represented by the transcendental equation would mean laborious calculation and plotting. It will be found to be a very close approximation to assume that this maximum bending moment was produced by a uniformly distributed load over the total length of the beam. This will readily give a curve which can be combined with the other moment curves represent-

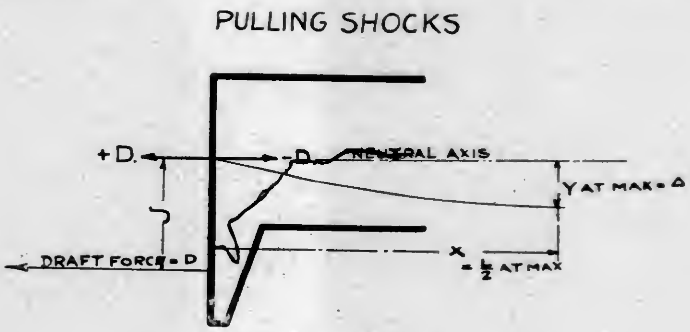


FIG. 13.

ing the conditions obtaining from static lading. Bending moment curves 8 and 9 are thus drawn.

The above procedure is best adapted to the careful investigation of a finished design more than to the preliminary choosing of trial underframe sections. For the latter a ready approximation can be made by considering the end bending moment simply as Rh or DJ and securing the uniform load which will give this corresponding moment at the center of the beam. Thus

$$RH \text{ or } DJ = \frac{wL^2}{8} \text{ and } w = \frac{8RH}{L^2} \text{ or } \frac{8DJ}{L^2}$$

which are equated moments taken about the point of intersection of the vertical center line between trucks and the neutral axis of the center sills. The uniform load is then assumed to be acting over the beam from end to end with the beam fulfilling the conditions of a simple beam with two supported free ends. This will give curves of the form as shown in 8, 9, 10 and 11, since R must be taken for both pulling and buffing. The vertical ordinates of the bending moment curves as drawn by this latter approximation will not be as large as if the more exact method had been used. The effect of this will be to cause the bending moment peak over the center plate to be slightly less and at the center of the car to be slightly greater in the curve 12, which represents the condition for buffing shocks from under hung draft gear combined with the vertical lading. The effect of this approximation upon curve 14, which represents the condition in which the pulling effects for the same draft gear hanging are combined with those of the vertical lading, is just the reverse of that for curve 12. The effects noticeable in curves 13 and 15, which are respectively similar curves for the overhung draft gear or rather draft gears so placed that the resultant end shock is above the neutral axis, are that 13 is affected the same as 14 and 15 the same as 12, which is practically a reversal of the whole condition as might be inferred from the end shocks acting on opposite sides of the neutral axis.

For the purpose of studying any car it is necessary to first

No.	CENTER SILLS OF C'T'R OF CAR	SIDE SILLS	TRUSS RODS
1	38" C TO C; 9"-21*	9"-21*	4 - 1¼"
2	34" C TO C; 5-12.25*; 6"	3½" x7; 6"-8"; 3½" x6"	1¼"
2₁	36"; 4x4x½"L; 5x3½"x½"Z	5"x3"x½"	
2₂ 5	24" C TO C; 6"-17.25*	5"x3"x½"	
3	24"x½"; 16½"; 12"-25*; 6"x1"	3"x3"x½"	2 - 1¾"
4	21½"x½"; 3½"x3½"x½"; 22"x⅜"; 13"; 3½"x3½"x½"	5"x3"x½"	
6	24"x½"; 3"x3"x½"L; 24"x5/16"; 14"; 3"x3"x5/16"; 3"x3"x5/16"L	3⅜"x5"; 4x3x5/16L; 3"x½"Z; 33; 5/16"; 3"x3"x⅜"	
7 15 16	16" C TO C; 12"-31.5*	3½"x7"x½"	2 - 1½"
8	16" C TO C; 10"-30*	6"x6"x½"	
9	24" C TO C; 8"-18*	6"x6"x½"	

No.	CENTER SILLS OF C'T'R OF CAR	SIDE SILLS	TRUSS RODS
10 11	½"x24"; 16½" C TO C; 18" 55*; 24"x½"	5"x3½"x9/16	
12 13 14	24"x½"; 16"; 18" 44.2*; 24"x½"	5"x3½"x9/16	
17 18	23½"x½"; 3½"x3½"x⅜"; 16"; 22"x5/16; 3½"x3½"x⅜"; 3½"x3½"x⅜"		
19	30"x⅜"; 24" C TO C; 12"-40*	6"x6"x½"	2 - 1⅞"
20	24"x5/16"; 3"x3"x½"; 16"; 5/16"x13½"; 3"x3"x½"; 24"x5/16"; 19"	5"x3½"x9/16	
21	16"; 9"; 8"-18*	6½"; 8"-18*	2 - 1½"
22	26"x½"; 16½"; 9-15*; 24"x⅜"	5"x3½"x5/16"	

CENTER AND SIDE SILL SECTIONS OF VARIOUS STEEL PASSENGER CARS.

The numbers correspond to those given in the table of data (Table 1) on page 457, December number.

know the disposition of the end shock and then three of the bending moment curves, 7, 12 and 13, or 7, 14 and 15, will tell all that is of import for underframe design. A combination of these three curves should be made in which the maximum ordinate for each abscissal point be chosen. This will give the moment that must be provided for in the design. These ordinates should not be combined algebraically as it is the single maximum which is required. Thus considering 7, 12 and 13, over the truck centers the moment from 12 should be chosen and for the center, the ordinate from 13.

This curve when drawn would seem to indicate a severe shearing point between P_3 and P_4, but such is not actually the case. This is due to the fact that it is not possible to have pulling and buffing strains simultaneously, yet they may occur in consecutive intervals of time and hence must be provided for. The character of this maximum strain must be considered for if tension, to it should be added the strains due to the axial component of the pulling, and if compression, it is necessary to include the unit compressive stress due to buffing.

There are many deductions that may be drawn from an inspection of these three necessary curves. Probably the most noteworthy is that from 12. It is seen that the moment over the center plate is severe whilst in the center of the car the moments due to end buffing shocks and vertical lading oppose each other, and with a sufficiently strong shock may reduce the resultant bending moment to zero. Investigation of 13 in comparison with 7 and 12 show that the moment over the center plate is decreased and in the center of the car increased for pulling loads. This shows the advantage of underhung resultant end shock over the overhung as the center bending moment is increased a smaller amount for the former than it would be for the latter. This is at the point where deflection is most troublesome.

The dotted lines in curves 5, 6 and 7 are introduced to illustrate how the central bending moment is reduced by removing the cantilever at P_4 and making the side girder sufficiently strong to carry all the load to P_3. This action is not quite as illustrated since P_3 is increased and hence the slope is somewhat sharper than shown by the dotted lines, but still falling within the full line.

These curves show that it is possible to place the intermediate cantilevers so that the moments over the center plate and at the center of the car are approximately equal for the maximum conditions. The use of additional cover plates in these regions of greatest stress may be necessary. This can be told graphically from the bending moment diagram by considering the moment a measure of the required section modulus which follows from the relation

$$\frac{I}{C} = \frac{M}{S}$$

The method of investigating an underframe by curves tells more than an elaborate mathematical treatment as it shows to the designer the whole stage of necessities at a glance. The value of the analytical treatment is found when it is desired to check some special sections for greatest stress to provide against possible error.

ANALYTICAL ANALYSIS.

All the special laws for the solution of beams are based upon the general principle that, "the bending moment at any section is equal to the moment of the reaction about that section minus the sum of the moments of the loads on the left of that section also about the section." For any beam loaded in a complex manner it is much simpler to solve for the bending moment according to this principle than to seek for suitable formulæ in handbooks covering such lading.

The following formulæ are based upon the same diagram (Fig. 11) as used for the graphical analysis.

From the average weights per foot on side and center sills as found under each heading we shall use those for express coach service as follows, in pounds per foot:

Total uniform side sill load = 830
Total uniform center sill load = 550

The weight of vestibule has been taken as 5,400 pounds and the end shock at 150,000 pounds pulling and 500,000 pounds buffing.

The loads with their arms and the bending moments are then as given in the table.

+ ↑ ↓ −	Forces in pounds.		Arm to section in feet.	Bending moment in foot pounds.
+	Reaction	$P_1+P_2+P_3+P_4+(x+a+b)\,550$	x	$P_1x+P_2x+P_3x+P_4x+550\,(x+a+b)x$
−	Platform end sill	P_1	$x+a+b$	$-P_1x-P_1a-P_1b$
−	Body end sill	P_2	$x+b$	$-P_2x-P_2b$
−	1st Inter-Cantilerer	P_3	$x-c$	$-P_3x+P_3c$
−	2nd Inter-Cantilerer	P_4	$x-c-d$	$-P_4x+P_4c+P_4d$
−	Uniform centre sill load	$550\,(x+a+b)$	$\frac{x+a+b}{2}$	$-275\,(x+a+b)^2$ *
−	End shock Load pulling	150,000	$J+\Delta$	$-150{,}000\,(J+\Delta) = -\frac{w}{8}(x+a+b)^2$ *

* Combined center sill load and end shock =

$$-\left(275+\frac{w}{8}\right)(x+a+b)^2 = -\left(\frac{2200+w}{8}\right)(x+a+b)^2$$

The total bending moment Mx is thus: =

$$550\,x\,(x+a+b) - P_1a - (P_1+P_2)\,b + (P_3+P_4)\,c + P_4d - \left(\frac{2200+w}{8}\right)(x+a+b)^2$$

the values of $P_1 = 2700$

$$P_2 = 2700 + 830\,\frac{b+c}{2}$$

$$P_3 = 830\,\frac{b+c+d}{2}$$

$$P_4 = 830\,\frac{d+e}{2}$$

substituted in the above, and the equation $15{,}000\,(J+\Delta) = \frac{w}{8}(x+a+b)^2$ solved for w and its value also substituted, give as a result:

$$Mx = \left(275-\frac{w}{8}\right)x^2 - \frac{w}{4}(a+b)\,x - \left(275+\frac{w}{8}\right)a^2 - \left(690+\frac{w}{8}\right)b^2 + 415\,(c+d)^2 + 415e\,(c+d) - \left(550+\frac{w}{4}\right)ab - 2700\,(a+2b)$$

There is but one variable in this expression as a, b, c, d, e and w are known from the design.

This bending moment table and the result show various relations between the loads and arms of the moments which we have touched upon in the discussion. The combination of the uniform center sill load and end shock into the form

$$\left(\frac{550}{2}+\frac{w}{8}\right)\left(x+a+b\right)^2$$

illustrates the ease with which the uniform center sill loading can simply be increased to provide for these end shocks. The direct axial stresses in the backbone should not be neglected in finding the required section modulus and area.

The value 150,000 pounds for pulling has been here used because the section chosen for x is near the center of the beam and the curves show this case to give the maximum moment in this region.

Now x can be taken at the other point of extreme moment, namely over the truck center. This will affect the table by reducing the reaction and all other load moments by everything to the right of the center plate. When it comes down to the last moment it becomes necessary to use the value of 500,000 $(H + \Delta)$ instead of 150,000 $(J + \Delta)$ for the minimum bending moment.

The formula as found is applicable to but the type of car under consideration and loaded as shown. The idea, in solving it, is simply to emphasize the procedure which should be followed for any particular class or form and to illustrate a feature, which is a consequence of the resultant equation, necessary to a consideration of interchangeability as found in our previous article.

For any car under process of design the formula will not look so formidable since there is but one unknown variable in the equation. The terms in a, b, c, d, e and w are known from the design so that there may be written as the final result

$$Mx = \delta (x^2) \pm f (x) \pm K$$

Putting this into words would mean that "the bending moment at any section between the truck centers is a certain function of x^2, plus or minus a different function of x, plus or minus a constant.

This can again be changed into the form

$$Mx = K_1 [(x \pm K_2)^2 \pm K_3]$$

which when divided by the stress will give a value of section modulus. Now knowing the section modulus furnished for a given type of underframe, this equation can be solved for the maximum length between truck centers, possible with a given underframe, to keep within the stress limits allowable. Or, again, it is possible to evaluate the equation for different values of $x = \frac{L}{2}$, when Mx is a maximum, and find a series of corresponding values of M. These values of M when combined with the permissible stress will give the requisite value of modulus of resistance.

Thus an underframe type may be chosen for all classes of service and cars of different lengths built upon it by changing the section modulus to suit the moments. An increase or decrease in the thickness of cover plates used or the weight of section for beams will usually be all that is demanded.

The work of mathematically designing the varying cars of unequal lengths and similar lading found in a complete equipment is measurably simplified by the adoption of this expedient. Throughout all the calculations for the stresses occasioned by the bending moments of both vertical and horizontal loads it should be carefully borne in mind that the direct axial stresses, tensile and compressive, have an effect in reducing the permissible straining of the girders by these moment loads. This is so frequently overlooked and not considered that it is deemed advisable to make it of particular note.

WALSCHAERT VALVE GEAR APPLIED TO CONSOLIDATION LOCOMOTIVE— CANADIAN PACIFIC RAILWAY.

WALSCHAERT VALVE GEAR.

CANADIAN PACIFIC RAILWAY.

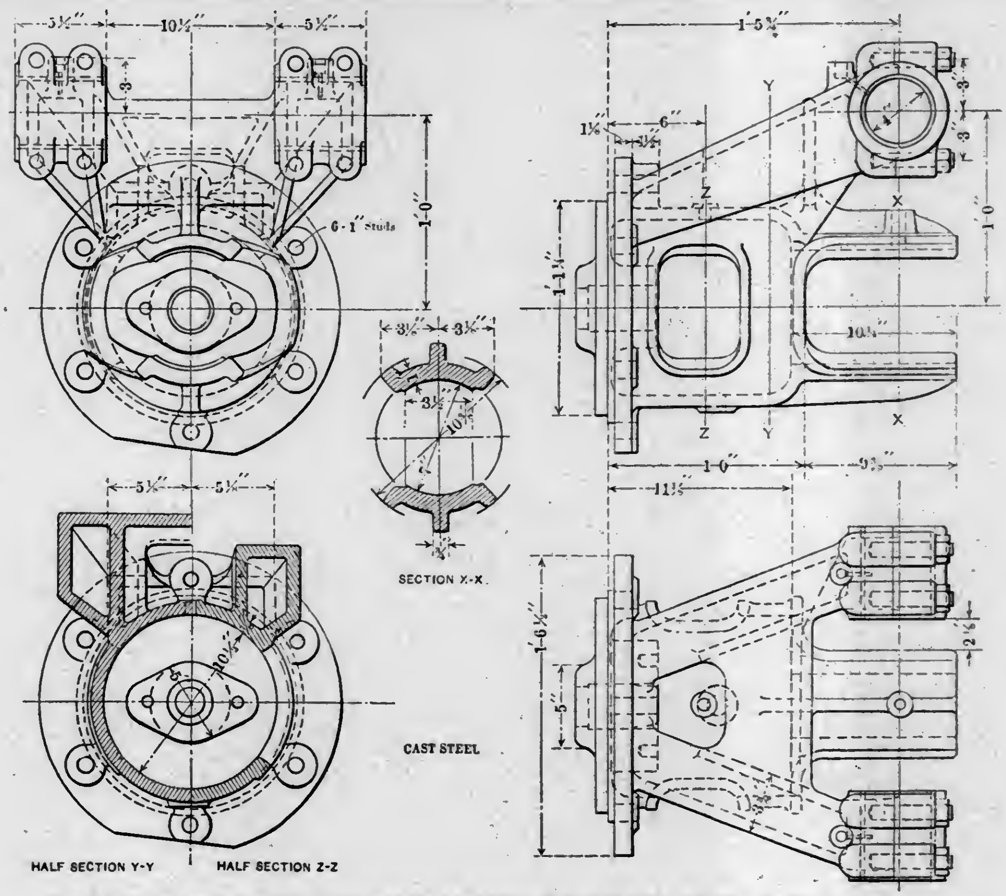
One of the prime essentials of any good valve gear is that the motion of the valve, when once set, shall be exact and invariable. This necessarily requires a substantial and rigid construction throughout, parts which are light but stiff, so they will not spring and bind; hardened bushings and pins to prevent wear and lost motion; ample bearing surface to allow efficient lubrication, and secure fastening of all carrying members to a practically rigid support. Experience has shown that these conditions are more easily fulfilled with a gear of the Walschaert type than with the Stephenson motion, and that locomotives so equipped remain square much longer. It will be noticed, however, that all of the recent designs of Walschaert gear are considerably heavier and more substantial in every way than were the earliest attempts, and it is now doubtful if a well designed Walschaert gear weighs less than a Stephenson motion for the same class of engine. This would indicate that in the earlier designs too much confidence was placed in the type alone and the parts were not made sufficiently stiff and strong to fulfil the duties of a successful motion.

Recognizing these conditions, the mechanical department of the Canadian Pacific Railway has recently designed a motion of this type, which is to be fitted to their standard class M-4 consolidation locomotives. (AMERICAN ENGINEER, May, 1906, p. 161.) It is so excellent an example of what a good valve motion should be, in which the possibility of the springing, sagging, or otherwise getting out of position of any part has been carefully avoided, that we devote considerable space to showing the detail parts.

This gear has been designed to suit the same cylinders and other parts that are used for the same class of engines having Stephenson motion so that at any time should it be desired, the Walschaert gear can be applied to the present engines without having to change any of the large and important existing parts.

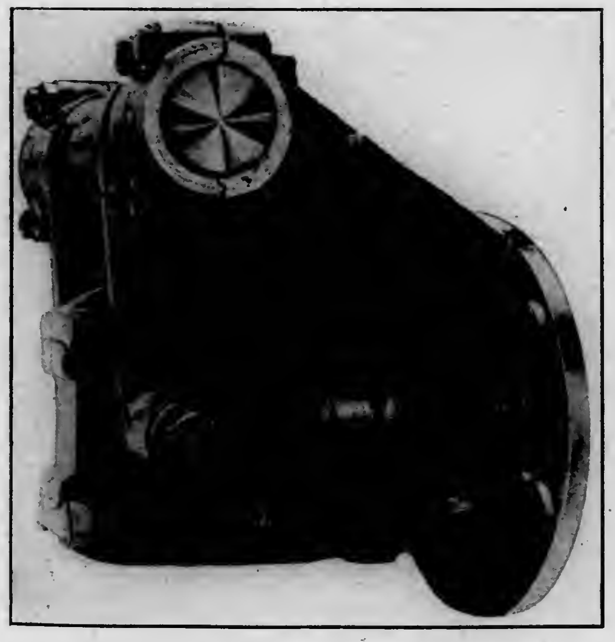
Ten new engines built and put into service during March and April were equipped with the motion and up to the present have given satisfactory results, and both the enginemen and those in charge of these engines speak very favorably of it.

The connection between the combination lever and the valve stem has been given careful attention to provide that the valve shall at all times move exactly in a horizontal line. This construction consists of a casting which forms, in one piece, the valve chamber head, a guide for the valve stem crosshead and



VALVE CHAMBER HEAD AND ROCKER BEARING, WALSCHAERT VALVE GEAR—C. P. R.

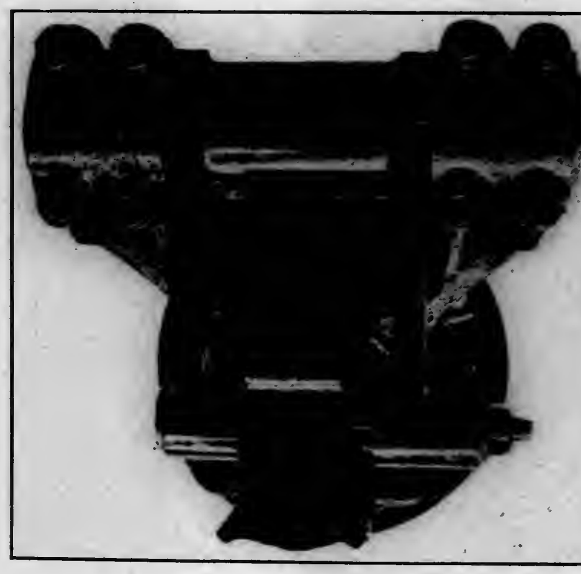
a bearing for the rocker arm which carries the weight of the combination lever and its connecting parts. This rocker has two downwardly projecting arms connecting to a block or small crosshead working in guides formed within the valve stem crosshead. The pin connecting the arms with the sliding block has an extension on the outside to which the combination lever



VALVE CHAMBER HEAD AND CONNECTIONS.

is connected. This construction thus provides a perfectly rigid support for the valve stem cross head and relieves it of the duty of carrying the weight of any of the parts of the valve gear. It also places the whole construction in a position where it will not interfere with the removal of other parts such as guides, front frame rail, spring rigging, etc.

The support of the link, reversing shaft and radius bar, which combined with their bearings, form a mass of considerable weight and must be supported some distance outside of the frames, has also been given careful attention to provide for perfect rigidity. These parts are carried by a deep cast steel guide yoke, having a bearing of more than 2 ft. in length on the main frame and a



ROCKER ARM, VALVE STEM CROSSHEAD AND SUPPORT.

depth of 16 in. over the frame. It is also provided with ample webs and flanges and liberal bearing surface at all points of connection with other parts. The link itself is of case hardened wrought iron in one piece and is bolted to a cast steel link carrier, which includes a shaft carried in two bearings placed 20 in. apart and secured to the guide yoke. The reverse shaft extends across the engine and is carried in two bearings secured just inside of the outer link bearing. This shaft has two cast steel

The formula as found is applicable to but the type of car under consideration and loaded as shown. The idea, in solving it, is simply to emphasize the procedure which should be followed for any particular class or form and to illustrate a feature, which is a consequence of the resultant equation, necessary to a consideration of interchangeability as found in our previous article.

For any car under process of design the formula will not look so formidable since there is but one unknown variable in the equation. The terms in a, b, c, d, e and w are known from the design so that there may be written as the final result

$$M_x = \pm a (x^2) \pm f (x) \pm K$$

Putting this into words would mean that "the bending moment at any section between the truck centers is a certain function of x^2, plus or minus a different function of x, plus or minus a constant.

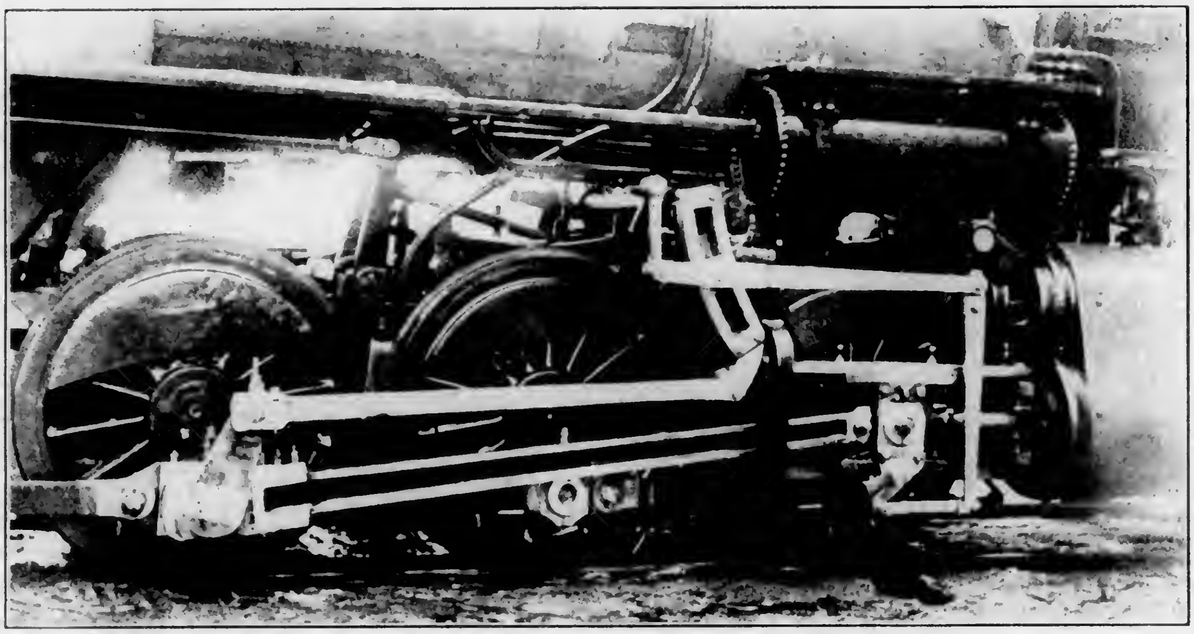
This can again be changed into the form

$$M_x = K_1 [(x \pm K_2)^2 \pm K_3]$$

which when divided by the stress will give a value of section modulus. Now knowing the section modulus furnished for a given type of underframe, this equation can be solved for the maximum length between truck centers, possible with a given underframe, to keep within the stress limits allowable. Or, again, it is possible to evaluate the equation for different values of $x = \frac{L}{2}$, when Mx is a maximum, and find a series of corresponding values of M. These values of M when combined with the permissible stress will give the requisite value of modulus of resistance.

Thus an underframe type may be chosen for all classes of service and cars of different lengths built upon it by changing the section modulus to suit the moments. An increase or decrease in the thickness of cover plates used or the weight of section for beams will usually be all that is demanded.

The work of mathematically designing the varying cars of unequal lengths and similar lading found in a complete equipment is measurably simplified by the adoption of this expedient. Throughout all the calculations for the stresses occasioned by the bending moments of both vertical and horizontal loads it should be carefully borne in mind that the direct axial stresses, tensile and compressive, have an effect in reducing the permissible straining of the girders by these moment loads. This is so frequently overlooked and not considered that it is deemed advisable to make it of particular note.



WALSCHAERT VALVE GEAR APPLIED TO CONSOLIDATION LOCOMOTIVE.—CANADIAN PACIFIC RAILWAY.

WALSCHAERT VALVE GEAR.

CANADIAN PACIFIC RAILWAY.

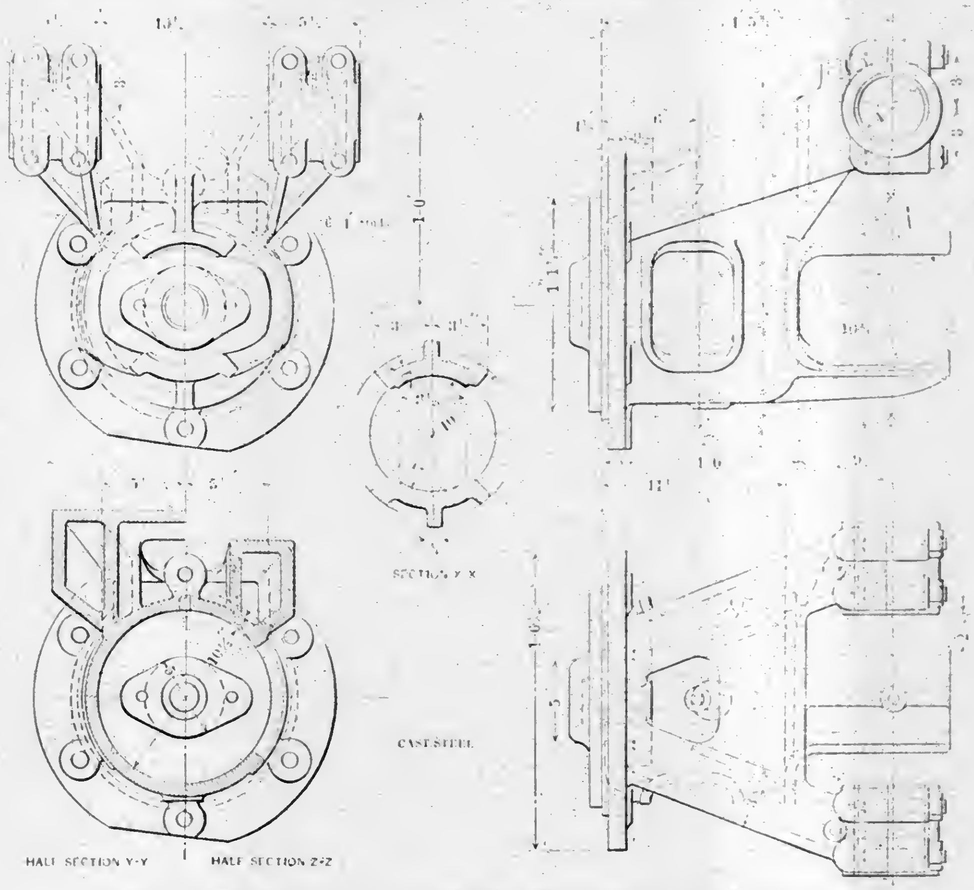
One of the prime essentials of any good valve gear is that the motion of the valve, when once set, shall be exact and invariable. This necessarily requires a substantial and rigid construction throughout, parts which are light but stiff, so they will not spring and bind; hardened bushings and pins to prevent wear and lost motion; ample bearing surface to allow efficient lubrication, and secure fastening of all carrying members to a practically rigid support. Experience has shown that these conditions are more easily fulfilled with a gear of the Walschaert type than with the Stephenson motion, and that locomotives so equipped remain square much longer. It will be noticed, however, that all of the recent designs of Walschaert gear are considerably heavier and more substantial in every way than were the earliest attempts, and it is now doubtful if a well designed Walschaert gear weighs less than a Stephenson motion for the same class of engine. This would indicate that in the earlier designs too much confidence was placed in the type alone and the parts were not made sufficiently stiff and strong to fulfil the duties of a successful motion.

Recognizing these conditions, the mechanical department of the Canadian Pacific Railway has recently designed a motion of this type, which is to be fitted to their standard class M 4 consolidation locomotives. (AMERICAN ENGINEER, May, 1906, p. 191.) It is so excellent an example of what a good valve motion should be, in which the possibility of the springing, sagging, or otherwise getting out of position of any part has been carefully avoided, that we devote considerable space to showing the detail parts.

This gear has been designed to suit the same cylinders and other parts that are used for the same class of engines having Stephenson motion so that at any time should it be desired, the Walschaert gear can be applied to the present engines without having to change any of the large and important existing parts.

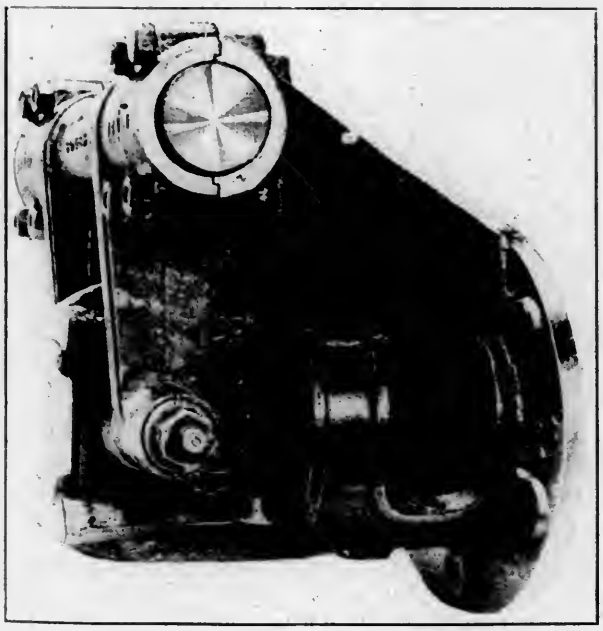
Ten new engines built and put into service during March and April were equipped with the motion and up to the present have given satisfactory results, and both the enginemen and those in charge of these engines speak very favorably of it.

The connection between the combination lever and the valve stem has been given careful attention to provide that the valve shall at all times move exactly in a horizontal line. This construction consists of a casting which forms, in one piece, the valve chamber head, a guide for the valve stem crosshead and



VALVE CHAMBER HEAD AND ROCKER BEARING, WALSCHAERT VALVE GEAR—C. P. R.

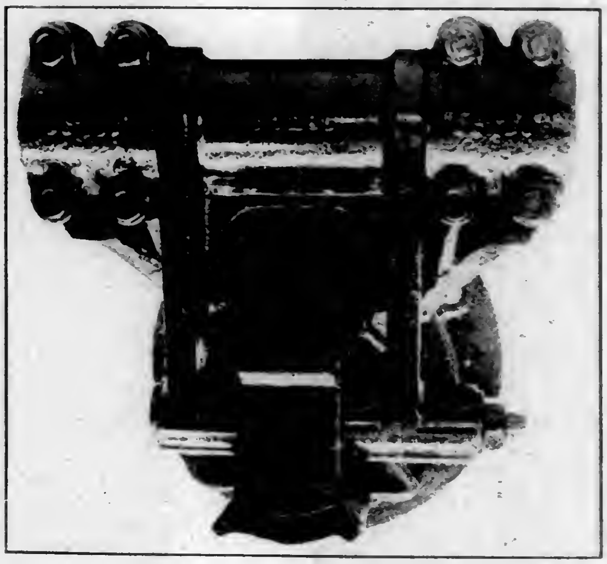
a bearing for the rocker arm which carries the weight of the combination lever and its connecting parts. This rocker has two downwardly projecting arms connecting to a block or small crosshead working in guides formed within the valve stem crosshead. The pin connecting the arms with the sliding block has an extension on the outside to which the combination lever



VALVE CHAMBER HEAD AND CONNECTIONS.

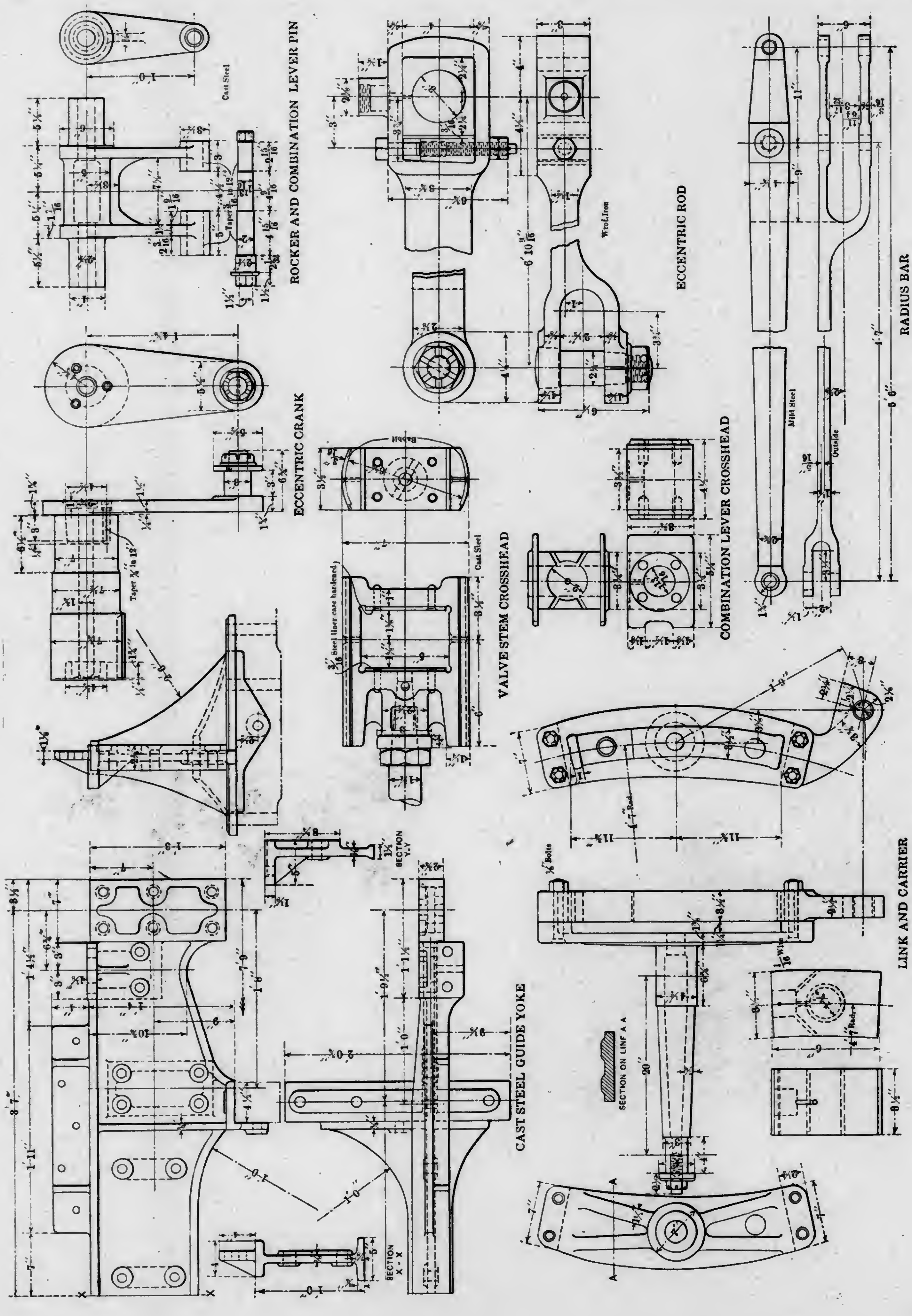
is connected. This construction thus provides a perfectly rigid support for the valve stem cross head and relieves it of the duty of carrying the weight of any of the parts of the valve gear. It also places the whole construction in a position where it will not interfere with the removal of other parts such as guides, front frame rail, spring rigging, etc.

The support of the link, reversing shaft and radius bar, which combined with their bearings, form a mass of considerable weight and must be supported some distance outside of the frames, has also been given careful attention to provide for perfect rigidity. These parts are carried by a deep cast steel guide yoke, having a bearing of more than 2 ft. in length on the main frame and a



ROCKER ARM, VALVE STEM CROSSHEAD AND SUPPORT.

depth of 16 in. over the frame. It is also provided with ample webs and flanges and liberal bearing surface at all points of connection with other parts. The link itself is of case hardened wrought iron in one piece and is bolted to a cast steel link carrier, which includes a shaft carried in two bearings placed 20 in. apart and secured to the guide yoke. The reverse shaft extends across the engine and is carried in two bearings secured just inside of the outer link bearing. This shaft has two cast steel



DETAILS OF WALSCHAERT VALVE GEAR AS APPLIED TO CONSOLIDATION LOCOMOTIVE—CANADIAN PACIFIC RAILWAY.

arms curved to clear the link and connect to the end of the radius bar back of the link. It also has a downwardly extending arm near the center which is connected to an arm on a reverse shaft, located in the standard position for the Stephenson link motion, which carries the counterbalance spring and connects to the reverse lever.

The radius bar, shown in one of the illustrations, is provided with a fork on either end, the forward one spanning the top of the combination lever and the back one spanning the link and link block. The eccentric rod, which is 6 ft. 10 9/16 in. long between centers is pinned to the extension on the link and has a split brass bearing at its connection with the eccentric crank. A wedge block is provided for taking up the wear in the brass.

The eccentric crank connection to the main pin consists of a boss 4½ in. in diameter and 3 in. high, which has a taper and draw fit in a recess in the main pin and is drawn up by a bolt passing through the center of the pin. The crank is set to a templet and three dowel holes are drilled and tapped and dowel pins screwed in, their heads being countersunk. This construction makes the eccentric crank practically an integral part of the pin and no provision is made for removing it under ordinary circumstances, since strap end main and side rods are used on the main pin.

The bearings throughout the gear are bushed with cast iron bushings hardened by the Meyers process and all pins are case hardened. The pins in practically all cases have a taper fit and projecting dowels. Single nuts slotted for split keys are used throughout. The provision for lubrication is very complete, as is shown in the illustrations of the details.

The setting of the gear provides for the eccentric crank to follow the pin and to have a throw of 16 in. When the pin is at the top quarter the eccentric pin is ⅝ in. below the horizontal center line. The parts are so proportioned as to give a valve travel of 6 in.

The following detailed statement of the weights of the Stephenson and Walschaert gears as applied to the same locomotives indicates the correctness of the opinion advanced above and shows the Walschaert gear to be 141 lbs. heavier:

WEIGHT COMPARISON.

STEPHENSON VALVE MOTION.

Part.	Weight.	No. per Eng.	Total Weight per Eng.
Guide Yoke Bracket	190 lbs.	2	380 lbs.
Guide Yoke	1,120 "	1	1,120 "
Steam Chest Cover	120 "	2	240 "
Rocker Box	127 "	2	254 "
Rocker	163 "	2	326 "
Transmission Bar	207 "	2	414 "
Link	160 "	2	320 "
Transmission Bar Hanger	40 "	2	80 "
Link Lifter	22 "	4	88 "
Reverse Shaft and Arm	300 "	1	300 "
Eccentric Rods	50 "	4	200 "
Eccentric Straps	202 "	4	808 "
Eccentrics	193 "	4	772 "
Crank Pin	280 "	2	560 "
Total			5,862 "

WALSCHAERT VALVE MOTION.

Part.	Weight.	No. per Eng.	Total Weight per Eng.
Guide Yoke Bracket	700 lbs.	1	700 lbs.
Guide Yoke	210 "	2	420 "
Steam Chest Cover	450 "	2	900 "
Rocker	150 "	2	300 "
Valve Stem Guide	50 "	2	100 "
Link	345 "	2	690 "
Outside Link Bearing	100 "	2	200 "
Inside Link Bearing	65 "	2	130 "
Lifting Shaft Bearing	100 "	2	200 "
Lifting Shaft	320 "	1	320 "
Lifting Arm	60 "	2	120 "
Lifting Arm (center)	110 "	1	110 "
Link Lifter and Pin	32 "	2	64 "
Reach Rod Intermediate	55 "	1	55 "
Reverse Shaft and Arms	250 "	1	250 "
Eccentric Rod	165 "	2	330 "
Radius Rod and Pin	120 "	2	240 "
Combination Lever	48 "	2	96 "
Union Link	23 "	2	46 "
Crosshead Arm	50 "	2	100 "
Crank Pin Complete	316 "	2	632 "
Total			6,003 "

Excess weight of Walschaert gear = 141 lbs.

SIGNAL TESTS.—During the month of October 2,245 surprise signal tests were made on the Pennsylvania Railroad, of which 98.8 per cent.. showed absolute perfection. Of the remaining 1.2 per cent. all trains were stopped, but had passed the signals by a few feet.

HEAVY SWITCHING LOCOMOTIVES FOR CLASSIFICATION YARDS.

CLEVELAND, CINCINNATI, CHICAGO & ST. LOUIS RAILROAD.

The American Locomotive Company is delivering from its Brooks Works two very powerful locomotives of the 0-10-0 type, designed for service in the classification yards of the Big Four Railroad. These engines are practically duplicates of those which were put into service on the Lake Shore & Michigan Southern Railroad about two years ago. (See AMERICAN ENGINEER, Sept., 1905, page 330.) The slight changes which have been made have increased the weight to 274,000 lbs., which gives a weight per driving axle of 54,800 lbs.

These locomotives were designed especially for handling the cars over the hump and are capable of pushing 3,000 tons on a .5 per cent. grade and 1,800 tons on a 1 per cent. grade. The 24 x 28 in. cylinders with 210 lbs. steam pressure and 52 in. drivers, give a tractive effort of 55,260 lbs., and as it is necessary for these engines to work at very low speeds and without slipping, a factor of adhesion of nearly 5 is used. The different boiler ratios are of about the average for freight locomotives, but the ratio of total heating surface to volume of cylinders is much larger than usual, because of the necessity of working at practically full stroke all the time.

Reference can be made to the drawings accompanying the article mentioned above on the Lake Shore & Michigan Southern engine for the details of this design and the general dimensions, weights and ratios are shown in the following table:

GENERAL DATA.	
Gauge	4 ft. 8½ in.
Service	Pushing in Yards
Fuel	Bit. coal
Tractive effort	55,360 lbs.
Weight in working order	274,000 lbs.
Weight on drivers	274,000 lbs.
Weight of engine and tender in working order	423,900 lbs.
Wheel base, driving	19 ft.
Wheel base, total	19 ft.
Wheel base, engine and tender	56 ft. 8½ in.
RATIOS.	
Weight on drivers ÷ tractive effort	4.94
Total weight ÷ tractive effort	4.94
Tractive effort x diam. drivers ÷ heating surface	625.00
Total heating surface ÷ grate area	81.50
Firebox heating surface ÷ total heating surface, per cent	4.10
Weight on drivers ÷ total heating surface	59.60
Volume both cylinders, cu. ft	14.70
Total heating surface ÷ vol. cylinders	314.00
Grate area ÷ vol. cylinders	3.85
CYLINDERS.	
Kind	Simple
Diameter and stroke	24 x 28 in.
Piston rod, diam.	4¼ in.
VALVES.	
Kind	Piston
Diameter	12 in.
Greatest travel	5⅜ in.
Outside lap	1 in.
Inside clearance	0 in.
Lead in full gear	¼ in.
WHEELS.	
Driving, diameter over tires	52 in.
Driving, thickness of tires	4 in.
Driving journals, main, diameter and length	10½ x 12 in.
Driving journals, others, diameter and length	9½ x 12 in.
BOILER.	
Style	Wagon top
Working pressure	210 lbs.
Outside diameter of first ring	80 1/16 in.
Firebox, length and width	108⅛ x 75¼ in.
Firebox plates, thickness	⅜ and ½ in.
Firebox, water space	4½ in.
Tubes, number and outside diameter	446—2 in.
Tubes, length	19 ft.
Heating surface, tubes	4412.7 sq. ft.
Heating surface, firebox	188.5 sq. ft.
Heating surface, total	4601.2 sq. ft.
Grate area	56.5 sq. ft.
Smokestack, diameter	20 and 24 in.
Smokestack, height above rail	14 ft. 10½ in.
Air pump	W. A. B. 11 in.
Air reservoir, number	2
Air reservoir, size	18½ x 120 in.
TENDER.	
Tank	Water Bottom
Frame	13 in. channel
Water capacity	7500 gals.
Coal capacity	12 tons

PREMIUMS TO EMPLOYEES FOR PATENTS.—A correspondent to the *Times Engineering Supplement* states that the German government railways have a fund for payment of premiums to employees who invent any appliance which may be useful in railway practice, and that during the last traffic year $3,700 was paid on that account to employees.

(Established 1832).

AMERICAN ENGINEER AND RAILROAD JOURNAL.

PUBLISHED MONTHLY

BY

R. M. VAN ARSDALE

J. S. BONSALL,

Business Manager.

140 NASSAU STREET, NEW YORK

R. V. WRIGHT,
E. A. AVERILL, **Editors.**

JANUARY, 1908

Subscriptions.—*$2.00 a year for the United States and Canada; $2.50 a year to Foreign Countries embraced in the Universal Postal Union.*
Remit by Express Money Order, Draft or Post Office Order.
Subscription for this paper will be received and copies kept for sale by the
Post Office News Co., 217 Dearborn St., Chicago, Ill.
Damrell & Upham, 283 Washington St., Boston, Mass.
Philip Roeder, 307 North Fourth St., St. Louis, Mo.
R. S. Davis & Co., 346 Fifth Ave., Pittsburg, Pa.
Century News Co., 6 Third St., S. Minneapolis, Minn.
W. Dawson & Sons, Ltd., Cannon St., Bream's Buildings, London, E. C., England.

Advertisements.—*Nothing will be inserted in this journal for pay,* EXCEPT IN THE ADVERTISING PAGES. *The reading pages will contain only such matter as we consider of interest to our readers.*

Contributions.—*Articles relating to Motive Power Department problems, including the design, construction, maintenance and operation of rolling stock, also of shops and roundhouses and their equipment are desired. Also early notices of official changes, and additions of new equipment for the road or the shop, by purchase or construction.*

To Subscribers.—*The* AMERICAN ENGINEER AND RAILROAD JOURNAL *is mailed regularly to every subscriber each month. Any subscriber who fails to receive his paper ought at once to notify the postmaster at the office of delivery, and in case the paper is not then obtained this office should be notified, so that the missing paper may be supplied.*

When a Subscriber changes his address *he should notify this office at once, so that the paper may be sent to the proper destination.*

CONTENTS

* Illustrated articles.

HANDLING ENGINE SUPPLIES.

The handling of engine supplies has not been considered as seriously as it should be in this country, because the possible savings appear small and it is hard to realize that much better service can be obtained in this direction by proper supervision at a very much less expense than it is now costing the average railroad. We have just received word, as we are about to go to press, that the article in this issue, which so clearly shows the possibilities in this direction, will be followed by two articles presenting detail methods, forms of accounting and drawings of standard equipment.

WALSCHAERT VALVE GEAR.

At its introduction, the claim that the Walschaert type of valve gear would save considerable weight over the Stephenson motion was advanced as one of the principal advantages of the gear and in the early designs this was a fact. Longer experience, however, showed the necessity of using stiffer and more rigid supports, which, taken in connection with the usual necessity of a change in the location of the piston valve chamber, making the cylinder casting of greater weight, has reversed these conditions and practically all locomotives now fitted with the Walschaert gear will weigh more than the same engines designed for and fitted with the Stephenson motion. The present widespread popularity of this type of valve motion shows, however, how little this matter of weight is actually considered in comparison with the other advantages of the gear. An example of this is shown in a design illustrated in this issue, which is being applied by the Canadian Pacific Railway. In this it is evident that the matter of weight, while carefully considered, was of secondary importance and the main object was to get a valve motion which would perfectly perform its functions even if it was found necessary to use extra parts and greater weight.

YOUNG MEN AND POSITIONS OF RESPONSIBILITY.

A superintendent of motive power, who has made a special study of the problem of organization and has under him a strong and loyal organization which is constantly developing leaders from among the younger men, has tried to impress the following thought on his subordinates:

"One of the common faults in those who have the management of large forces is that of not thoroughly understanding the elementary fact that if we desire to keep our positions as foremen and executives it is necessary to keep our forces young. To make this clear it may be truly said that if we keep our forces young it does not matter how old we may be ourselves, we will be practically sure of retaining our positions."

"It should be distinctly understood that men are capable of accepting positions of responsibility when they are very young. As an illustration we might say that when a man is twenty-one or twenty-two he should be advanced to a position of responsibility where it is necessary for him to handle a number of men. The common fault lies in the fact that we usually consider those under us young if they are slightly younger than ourselves."

"Following out this line of thought, it is easy to see that a man of seventy-five would consider a man young who was seventy-four and would quite likely only promote those who were near his own age. Therein lies the mistake. The man of seventy-five should realize that in order to have an efficient organization he should promote men of twenty-one or twenty-two years of age to positions of responsibility."

STEEL FREIGHT CAR REPAIRS.

About 55 per cent. of the freight cars belonging to the Pittsburgh & Lake Erie Railroad are of steel construction. For a number of years the repair work on steel cars was done in the open and with very few special facilities. During the greater part of this time the rebuilding of the locomotive and car shops at McKees Rocks was under consideration and when the plans for the car department, which was the last to be completed, were finally adopted the railroad had not only a very extensive experience in the repair of this type of car to guide it, but it had also been able to give the question very careful consideration and study in order to make the facilities for handling this class of work as complete and effective as possible. In view of these facts the first article in this issue will prove especially valuable to those who are interested in this work. Except for the building, which is of rather expensive construction, the facilities are comparatively simple and not nearly as costly as might be expected. The method of carrying a complete supply of all parts, so that damaged parts can be quickly replaced with new ones in order to get the car back into service with the least possible delay, is important. The use of

overhead cranes simplifies the organization, as the men can be divided up into gangs of two men each instead of four or five, or possibly more, as is necessary where cranes are not provided.

Not the least interesting part of the work of this department is the repainting of the cars with spraying machines. It is doubtful whether any road has better painted cars, and the spraying machine as used on the Pittsburgh & Lake Erie Railroad has certainly given a splendid account of itself during the time in which it has been used, which covers a period of several years. It is surprising that the spraying machine is not more extensively used on other roads.

PRACTICAL WORK IN CONNECTION WITH COLLEGE TRAINING.

Some provision should be made in the engineering courses of our colleges and universities to have the students receive training in practical work, either previous to or at the same time that they are receiving their college training. By practical work we do not mean work in the college workshop but in connection with some industrial or engineering concern. It is surely wrong to graduate a man from college and turn him out into the world with an engineer's degree without his having done any practical work at all. It is even a more serious matter to give such a man a position on the teaching staff, placing him in charge of other students.

Professor H. Wade Hibbard, in charge of the department of railway mechanical engineering of Cornell University, has, ever since he took up college work, tried to impress the engineering students, with whom he came in contact, with the importance of working in the shops during summer vacations, in order that they might have a better understanding and appreciation of their work in college and be better fitted to take responsible positions when they were graduated.

Professor Hibbard has kindly furnished us with the names of the members of the class who are now taking his major course in railroad mechanical engineering, consisting of four lectures a week during the senior year; also data as to just what practical experience each of these young men has had, as far as he has been able to ascertain.

Ninety-three students are taking this work up and the previous experience of all but twelve of them had been found when the data was sent to us. Of the remaining eighty-one, eleven, or about 13½ per cent., have apparently had no business experience at all. Four have worked during summer vacations but in lines which were not allied to engineering work. Of the remaining sixty-six all have had experience, more or less, in work which was in some way allied to engineering of some kind, including work in railroad and manufacturing shops, automobile repairing, mining work, the manufacturing, repairing and testing of electrical machines, etc. In the following statement, showing just how many months of experience each boy has had, three months have been allowed for a summer vacation.

A number of the young men have had considerable experience in other lines, which is of course not included in this statement. The data for three men was a little indefinite and could not be included. One of these worked in the factory of a lead works and had had some experience in the drafting and advertising department of an electric company. Another had spent several summers in automobile garages and repair shops. Another had been engaged in electrical testing and electric railway installation. Sixteen had between one and three months' experience; sixteen five or six months; thirteen from seven to nine months; six from ten to twelve months; seven from fourteen to eighteen months; one, twenty-one months; one, thirty-three months; one, forty-three months; one, fifty-four months, and another five years in addition to several summer vacations.

This indicates a gratifying condition at Cornell and the same thing is possibly true at a few other institutions where members of the faculty have realized the importance of urging the students to spend their summer vacations in this way. It is to be regretted that more college professors do not realize the importance of doing this.

GRAND TRUNK APPRENTICE SYSTEM.

The Grand Trunk Railway System has had an efficient apprentice system in force in its shops for several years with very satisfactory results. It includes a thorough shop training and a course in mechanical drawing, simple mathematics and applied mechanics. At the present time the road has 233 apprentices.

Entrance Requirements.—The applicant must be in good health, free from bodily defects and not less than 15, nor more than 18 years of age. He must file an application with the local master mechanic or general foreman, giving his age, the grade to which he had advanced before leaving school and the positions in which he had been employed since that time. He is then required to undergo a medical examination by the railroad company's resident medical officer. If this proves satisfactory he is given an examination in the master mechanic's or general foreman's office, which is conducted either by the chief clerk or some one specially appointed for that purpose. It includes a test in eyesight and reading, in which the applicant must be able to read extracts from the instructions at the end of the employees' time table (set in seven point or minion type), standing 30 inches from it. His hearing and spelling are tested by writing a letter from dictation, applying for employment at the shops. He must also be able to solve correctly such examples as the following: Multiply 122,983,672 by 527,001 and divide 723,643,978 by 365.

If the applicant passes this examination satisfactorily he is required to copy the written part of it in a record book, so that a complete record of his ability from the day he enters the service will be on file. If he fails to pass the examination he may, if thought advisable, be given a place as a rivet or hammer boy. These boys are taken on probation for one season and if at the end of that time they are still unable to pass the apprentice entrance examination they are dismissed from the service.

Indenture.—The apprentice is indentured for the term of his apprenticeship, the papers being signed by himself and his parent or guardian. He must not join any organization which claims or attempts to control his action or labor in any way. He is required to attend the evening classes for instruction in mechanical drawing and mathematics. If during the first year of his apprenticeship he should prove unfitted, physically or mentally, to acquire the trade, the agreement becomes invalid. The company is allowed to retain five cents per day of his wages, which will be paid to him at the end of his term upon the faithful and full performance of his apprenticeship duties. The company also agrees to pay him a bonus of $25.00 when his apprenticeship has been satisfactorily completed. The schedule of wages for the term of apprenticeship is shown on the indenture papers.

It is claimed that this system has a tendency to keep the apprentice better satisfied and to have him become more interested in his work. It also prevents other concerns from tampering with him and getting him to leave the railroad company after it has given him partial instruction in the trade, and he is beginning to become useful to the company.

Shop Training.—After successfully passing his entrance examinations and signing the indenture papers, the apprentice may be assigned to either the blacksmith shop, boiler shop, or any shop, other than the machine and erecting shop, where he is required to remain for a period varying from six to nine months. He is given a text or instruction book which covers his entire apprenticeship and contains the answers to questions which he will be required to answer correctly before being promoted from one class of work to another. This text book is about 4 x 7 in. in size, has heavy card-board covers and contains about 25 pages. Before being promoted to the machine shop, which is the next step and where he will be started to work on a drilling machine, he must pass an examination as outlined in the text book, and which is partially reproduced in this article. If he cannot pass the examination satisfactorily, he is put back in the shop in which he was working and the next apprentice in line is examined, and if successful is promoted. If the first apprentice cannot pass the examination the next time there is an opportunity for promotion he is dismissed from the service, or is given some minor position outside of the trade.

GRAND TRUNK RAILWAY SYSTEM

MOTIVE POWER DEPARTMENT

EXAMINATION QUESTIONS FOR APPRENTICES

PRACTICAL MECHANICS

APRIL 1907

6
1. Add together 22.4624, 2.3021, .012, 2.3020, 15.01 and 142.2133.
2. Add together 143.5121, 3.651, 10.0002 and 271.28.
3. Add together .06, .0031, .0003, 316.0006 and .000004.

6
4. Subtract 28.9 from 32.96571.
5. Subtract 3.002002 from 4.62.
6. Subtract 32.614632 from 41.

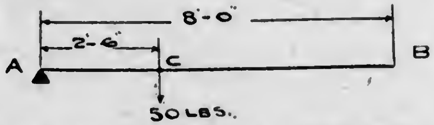
7
7. Multiply 36.2712 by 4151.
8. Multiply .00367 by 6.511.
9. Multiply .00002463 by 86.

8 [4]
10. Divide 482.613 by 265.
11. Divide 8.75061 by 23563
12. Divide 783.5 by 5206.

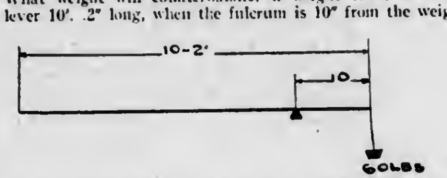
9 [5]
13. Find the circumferences of circles whose diameters are 16", 16.5", 18" and 22"
14. Find the circumferences of circles whose diameters are 64", 75", and 89"

9 [5]
15. Find the areas of circles whose diameters are 23", 25", and 30".
16. Find the areas of circles whose diameters are 35", 39", and 45".

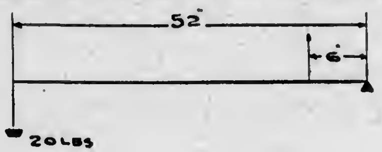
11 [7]
17. In a lever A C B, 8 feet long, supported at A, a weight of 50 lbs. is hung at C, 2' 6" from A. What force applied at B will balance it?



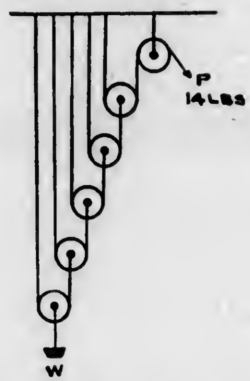
11 [7]
18. What weight will counterbalance a weight of 60 lbs. on a lever 10'. 2" long, when the fulcrum is 10" from the weight?



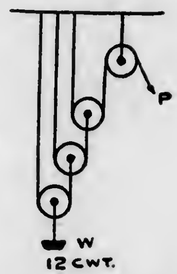
11 [7]
19. A lever 52" long, fulcrum at one end, 20 lbs. weight at the other end, find what weight at 6" from fulcrum will balance it?



11 [7]
20. In the first system of pulleys, what weight will a power of 14 lbs. support by means of 5 pulleys. Answer in lb.

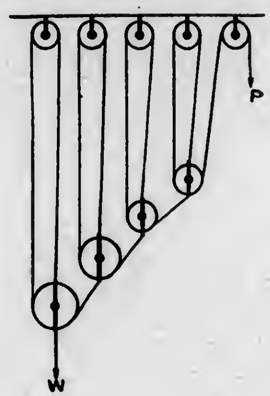


21. In the first system of pulleys, what power will support a weight of 12 cwt. by means of 3 pulleys. Answer in cwt.

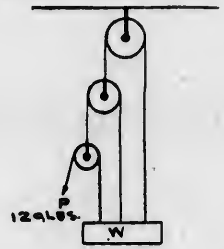


11 [7]
22. In the second system, what weight will be supported by 4 cwt. with 4 pulleys? Answer in cwts.

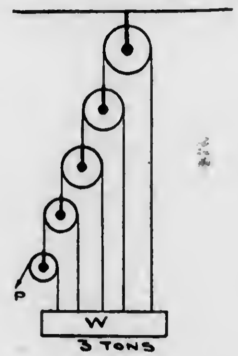
23. In the second system, what power will be required to balance a weight of 2 tons with 4 pulleys? Answer in cwts.



[10]
21. In the third system, what weight will a power of 120 lbs. support with 3 pulleys?



25. In the third system, what power will balance a weight of 3 tons with 5 pulleys? Answer in cwts.



[11]
26. The piston speed of an engine is 10 feet per second. How many miles will the piston travel in an hour?
27. A railroad train travels 60 miles in one hour What is the velocity in feet per second?

[10]
28. A body A moves at the rate of 12 feet per second and another B, starting from the same place in the opposite direction at 14 feet per second. Find the distance between them after 10 seconds.
29. The outside diameter of an engine fly wheel is 13'. 9", a point on the rim travels 45,000 feet in 5 minutes. What is the velocity in feet per second?

[10]
30. A train weighs 400 tons, the resistance=10 lbs. per ton. Find work done in drawing it one mile at uniform speed. Answer in foot lbs.
31. A hole is punched through a ½" steel plate. The pressure necessary is 34 tons. Find work done. 1 ton=2240 lbs. Answer in foot lbs.

[10]
32. A chain 100 feet long, hangs from one end, weight 12 lbs. per foot. How much work is done in coiling it on a drum? Answer in foot lbs.
35 In question No 32 how much work is done in raising the lower end of chain to meet the upper end. Answer in foot lbs.

Rules Governing Examination of First Year Apprentices.

Questions Nos. 1 to 23 are for the above class, although not more than 11 questions are to be attempted. The number of marks for each question in this class is shown thus $\overset{\wedge}{\underset{\vee}{11}}$. It is only necessary to answer one out of Nos. 1, 2 and 3, one out of Nos. 4, 5 and 6, one out of Nos. 7, 8 and 9, one out of Nos. 10, 11 and 12, one out of Nos. 13 and 14, one out of Nos. 15 and 16. Work out 17, 18 and 19, one out of 20 and 21 and one out of 22 and 23.

Rules Governing Examination of all Apprentices Other than First Year.

Questions 10 to 33 are for this class, although not more than 13 questions are to be attempted.

The number of marks for each question in this class is shown thus [11]. Commence at example 10, 11 or 12.

It is only necessary to work one out of 10, 11 and 12, one out of 13 and 14, one out of 15 and 16, work out 17, 18 and 19, one out of 20 and 21, one out of 22 and 23, one out of 24 and 25, one out of 26 and 27, one out of 28 and 29, one out of 30 and 31 and one out of 32 and 33.

GENERAL RULES

Marks will be allotted according to neatness and accuracy, and each set of questions must be pinned together for each pupil.

Always place the number of question close to the working for each problem.

Marks for first year apprentices are shown thus $\overset{\wedge}{\underset{\vee}{11}}$.

Marks for second year apprentices are shown thus [11].

The time allowed for this examination will be two hours.

The following are extracts from the text book:

EXAMINATION FOR PROMOTION OF APPRENTICES FROM OTHER SHOPS TO THE MACHINE SHOP.

Q.—What is the weight of standard shop hammer (machinist's hand)?
A.—Two pounds.
Q.—At what point should hammer be held for efficient service?
A.—At the extreme end of handle.
Q.—What is the length of hammer handle?
A.—Sixteen inches over all.
Q.—How many classes of drills are in general use in this shop?
A.—Two, viz: flat and standard twist drills.
Q.—At what degree is the cutting end of twist drill ground?
A.—Fifty-nine degrees, measuring angle from the centre line of drill.
Q.—Name the speeds for drilling brass, cast iron, wrought iron and steel, different size holes, with carbon steel drills, and air hardened steel drills.
A.—As per table* and as much faster as drill and material will permit.
Q.—Name the speeds for tapping steel, iron and brass, different sizes.
A.—(Table.)*
Q.—What size should holes be drilled for tapping various sizes?
A.—(Table.)*
Q.—What lubricant is used for drilling wrought iron or steel?
A.—A mixture prepared in the shop consisting of oil, soap and water (boiled), or lubricant, as may be furnished.
Q.—What is a center punch used for?
A.—Marking center of holes for drilling and indicating lines on other machine work.
Q.—What is a round nosed chisel used for at drilling machine?
A.—Drawing centers.
Q.—Which side of a belt should be run next to pulley or cone?
A.—Smooth or grain side.
Q.—What are the general rules to be observed regarding cleanliness and care of machines?
A.—All cuttings of different materials are to be kept separate. Machine to be cleaned thoroughly once per week in addition to ordinary daily cleaning, and all working parts kept properly lubricated. Marking or defacing machine in any way to be carefully avoided.
Q.—Explain the reading of an ordinary standard measuring rule.
A.—Apprentice will explain practically from rule.
Q.—How many, and what are the names of the different classes of calipers in general use on drilling machine?
A.—Three: inside, outside, compass or hermaphrodite.
Q.—What tools are necessary for laying off or measuring work at drilling machine?
A.—Inside, outside and compass caliper, dividers, center punch, rule, square and surface gauge.
Q.—What is a jig?
A.—A device for standardizing and duplicating parts, and is a casting or plate fitted with hardened steel bushes which form a guide for drilling, slotting, turning or planing.
Q.—What are its advantages?
A.—Insures perfect accuracy, abolishing the marking off system for machining.
Make drawing of a mogul crank pin, half size; drawing to be inked in.

PROMOTION FROM DRILL TO SHAPER OR PLANER.

Q.—How should work to be planed or shaped be secured?
A.—By means of bolts or clamps, or in a vise, care being taken not to spring or distort the material.
Q.—What are the usual tools in connection with shaper or planer?
A.—Usual standard tools, special tools for special work.

* Omitted for want of space.

Q.—What is the cutting speed per minute for the following classes of material: Steel, wrought iron, cast iron and brass?
A.—Steel and wrought iron, 30 to 35 ft.; cast iron, 30 to 35 ft.; brass, 120 ft.; speed to be exceeded in all cases where possible; reversing speed of planers to be from 100 ft. to 125 ft. per minute.
NOTE.—Planers to be fitted with countershafts to regulate speed for different classes of material.
Q.—What tools are used for setting up work?
A.—Square, surface gauge, and other tools, as described in use on drilling machine.
Make a drawing of mogul big end strap, half size. Drawing to be inked in.

NOTE.—Apprentices will make pencil drawings on paper.

Following the above are questions and answers of the examinations for promotion from the planer or shaper to the lathe, and for promotion from the lathe to the fitting or erecting department. The book also contains similar information concerning the final examination which must be passed before the apprentice can be promoted to the position of journeyman. By having the apprentice pass an examination on a certain class of work, before he takes it up, he gains a general knowledge of it in advance and is encouraged to think more about this work and to observe carefully what is going on about him.

Apprentices in machine work and fitting are required to serve five years; apprentices in other departments are required to serve only four years. These latter must pass the entrance examination and the first of the examinations in the text book, the same as the machinist apprentices. After that they rely for their shop training entirely on the foremen and are only required to take the yearly examinations in drawing and mathematics.

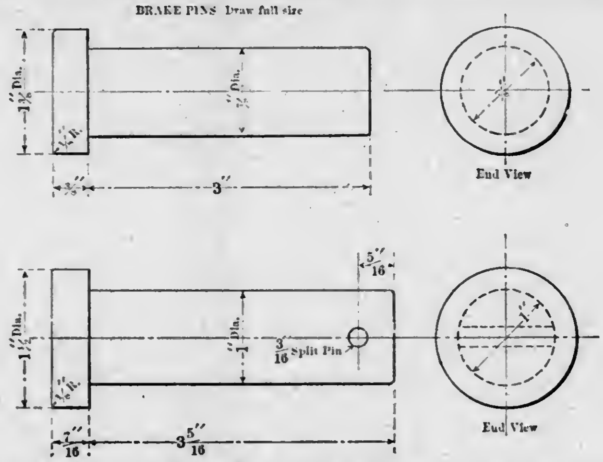
As the shops are practically all operated on a piece-work basis, and the apprentices are pro-rated with the journeymen, it is not thought necessary to have special shop instructors, as it is to the interest of the journeymen to see that the boys understand their work properly.

A record of the shop work of each apprentice is kept, similar to the ones illustrated. These records are made by the chargeman, under whom the boys are working and are examined by the foreman and sent to the master mechanic's office each month.

Class Work.—The apprentices are required to attend evening classes (7.30 to 9.30) twice a week from October to April. These are in charge of competent instructors, and the course includes a thorough training in mechanical drawing, arithmetic and applied mechanics. This instruction, together with the necessary material, except the drawing instruments, which must be provided by the apprentices, is furnished free of charge by the company. The boys are not paid for the time put in in the class room. Apprentices who do not attend the classes regularly, and do not have a good excuse for not doing so, are discharged.

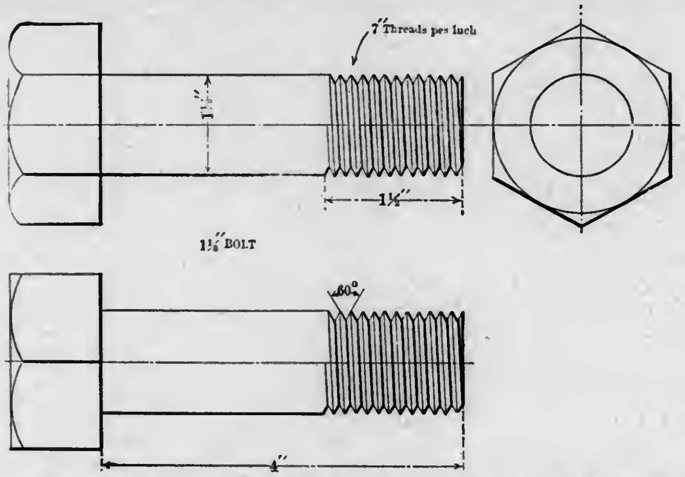
A carefully prepared drawing course has been laid out, which can be covered by the average apprentice in about three years. After that he is asked to draw different parts, making his own rough sketches and working directly from the object, and without special instruction.. He is also given practice in making general or assembled drawings. When the apprentice first reports to the class he is given instructions in a blue print pamphlet as to how to go about his work and use his tools. Also information as to the method of laying out his drawing sheet, lettering, figuring, etc. No time is wasted on geometrical exercises. The first part of the course consists almost entirely of redrawing the exercises to a different scale, the subjects treated being such as the apprentice is familiar with in connection with his shop work.

The first exercise is illustrated in Fig. 1. It wll be seen that the apprentice is required to use his compass from the very first, and that he must draw this exercise several times until he becomes somewhat accustomed to the use of his tools. He is also expected to shade the rounded portions, as all drawings which are made in the Grand Trunk drawing office are shaded thus. The second exercise is for a wrought iron link and lever and also requires the use of the compass and dotted or invisible lines; in addition it requires the use of the 45-degree triangle. The third exercise shows three links of a standard chain. The fourth, which is reproduced in Fig. 2, is for a 1⅛-in. bolt, and in addition to the principles already introduced, calls for the drawing of a hexagon and the drawing of threads. The seventh exercise



Draw the 7/8" pin first and after completing the two views of same, draw again and even a third one, then proceed with 1" pin, which draw several times.

FIG. 1.—FIRST EXERCISE.



In drawing bolts the following rule should be observed: the diameter of bolt being given, thickness of head and also nut will be equal to that diameter, the distance across corners or angles equal to twice the diameter. This is not altogether correct but is done to simplify the drawing of bolts.

FIG. 2.—FOURTH EXERCISE.

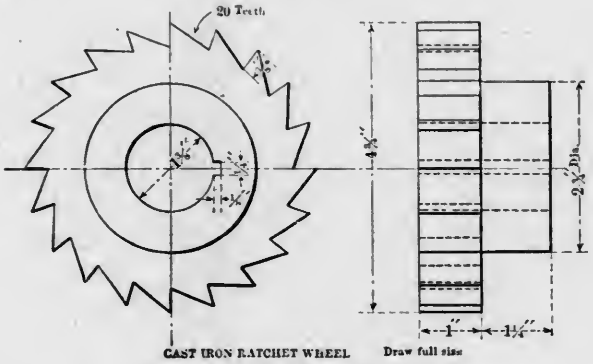


FIG. 3.—SEVENTH EXERCISE.

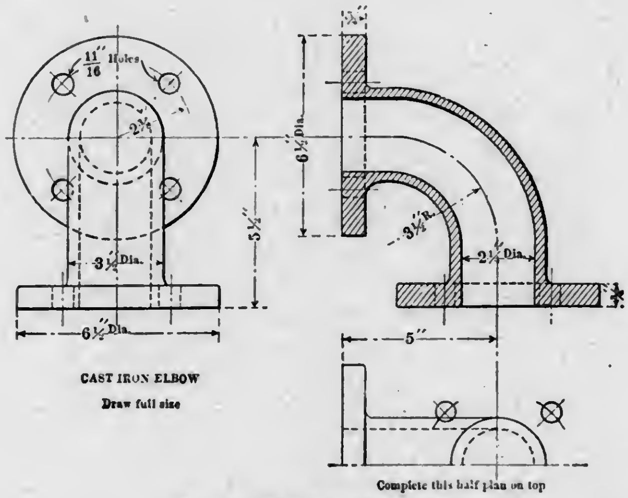
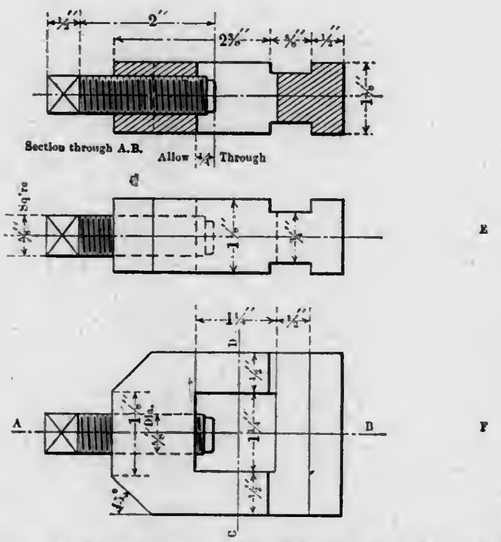


FIG. 4.—TWELFTH EXERCISE.



Draw also end elevation at point "E," looking on top of screw. Show also section at point "F" through "C," "D," the left hand portion being removed.

FIG. 5.—NINETEENTH EXERCISE.

introduces the principle of dividing a circle and is shown in Fig. 3. The eleventh exercise introduces the conventional method of showing threads. The twelfth exercise, shown in Fig. 4, is the first to require sectioning. In the first eighteen exercises the apprentice is not required to introduce any new views. The nineteenth exercise, which is a tool holder for a shaping machine, requires the drawing of two additional views, as shown in Fig. 5. From this point the exercises are varied, some being quite difficult, but with simpler ones intervening, so that the student is encouraged in his work and can realize that he is making progress. The thirty-fourth exercise, which is the last one of this part of the course, is the drawing of a driving box, and is shown in Fig 6.

In connection with the mechanical drawing the student is given a course in practical mechanics. This course is outlined in a little book which has been prepared by Mr. James Powell, the chief draftsman, and with the aid of it the instructor directs this part of the class work. The student is first given problems in simple arithmetic, and as he becomes proficient in this is gradually advanced until, at the end of his apprenticeship, he is expected to have a good working knowledge of the simpler laws of mechanics and the properties of materials. The outline by Mr. Powell has an appendix containing tables of the areas and circumferences of circles and the decimal equivalents of the fractional parts of an inch and of a foot. Also information concerning steam, water and gas pipes and threads for pipes and bolts. A brief history of the locomotive is also given.

In the spring of each year examinations in drawing and mathematics are held over the entire system, in which every apprentice is required to participate. Five sets of questions are prepared, one for the apprentices in each year. The questions for the examinations in mathematics held last spring are reproduced complete. This course had, up to that time, only been in force for about two years and for that reason the questions for the apprentices in the second, third, fourth and fifth years were the same. These questions will give a fair idea of the ground covered in two years time by the course in mathematics. Examinations are held in mechanical drawing at about the same time, the apprentice being required to make two or three pencil drawings in two hours time. The examination questions for the first and fifth year apprentices are reproduced.

The examination papers are all numbered and the boy's name, with the number of his paper, is placed in a sealed envelope, which is sent with the examination papers to the office of the chief draftsman at Montreal, who examines and marks them. To encourage the boys in their studies prizes are offered to those

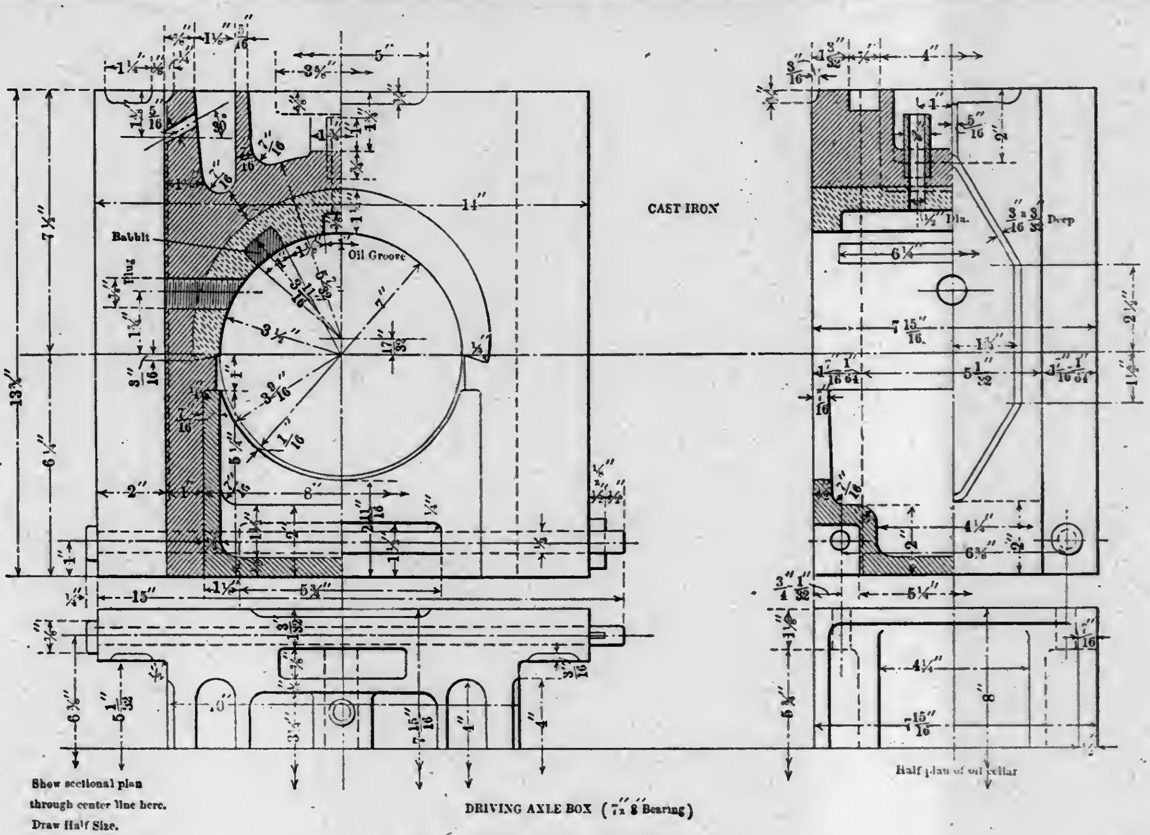
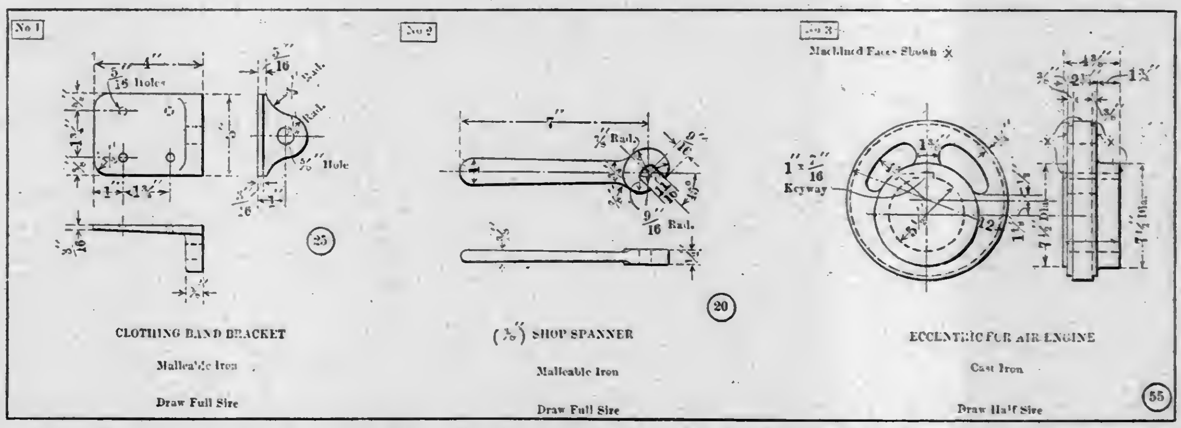


FIG. 6.—THIRTY-FOURTH EXERCISE.



Draw the above as indicated, printing title, notes, etc., in each case. The value attached to each question is shown thus (55). Total number of marks obtainable = 100. Always place the number of the question alongside your work. Do not copy errors.

MECHANICAL DRAWING EXAMINATION. FIRST YEAR APPRENTICES.

who have the best standing in each class at each shop. Special prizes are also given to the apprentices, in each class, having the highest standing on the system. The class obtaining the highest average on the system is also given a special prize. The boys take a great interest in this competition, and there is keen rivalry between the apprentices in each shop and between the various shops. Many of the boys devote considerable time out of class in studying along the lines prescribed in the course, in order to make a more creditable showing at the examinations. The railroad company has two scholarships at McGill University which are open to the apprentices making the best records.

Wages.—The rates are governed by the schedules for each shop which are authorized by the superintendent of motive power.

FOREMAN'S APPRENTICE RECORD.

Name	Shop	Month 1905	Workmanship				Conduct				Attendance				REMARKS
			7	14	21	31	7	14	21	31	7	14	21	31	
J. French......	Erecting	January	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	½ day off for funeral
A. McDonald..	"	"	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	
F. Finch.	"	"	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	

Noted:

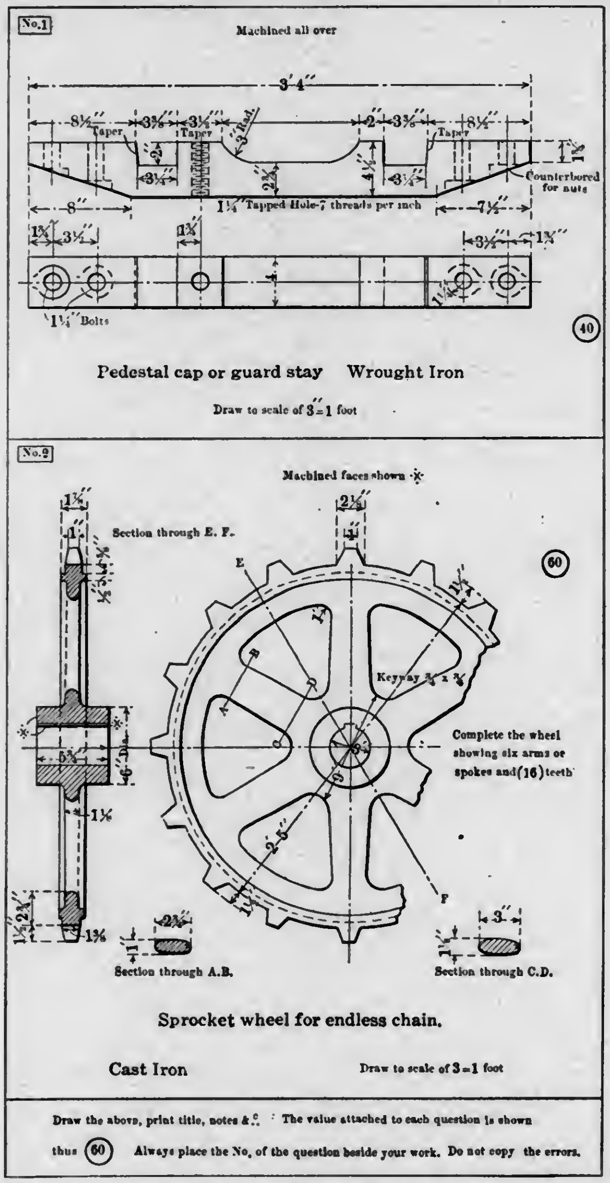
Master Mechanic.

Results.—The Grand Trunk System has taken a greater or less interest in its apprentices for many years, but just previous to the establishment of the new system a few years ago, as out-

lined above, it had been somewhat neglected, and it was found difficult to get a good class of apprentices and workmen. The difficulty of obtaining good apprentices almost immediately disappeared upon the establishment of the present system. Under the old system, when the entrance requirements were not so rigid, parents would take their boys out of school at 13 and have them work at some other shop for two years, and then have them start to work at 15 in the railroad shops. Now it is necessary for them to keep the boys at school longer in order that they may "make good" when they enter the service of the railroad. In addition to recruiting the force in the shops, and providing the company with a better grade of mechanics, a number of the boys have developed into first-class draftsmen, and have been found to be much more valuable to the company than the average draftsman, who has little or no shop experience.

Graduation.—At the end of his term the apprentice is required to take an examination in shop practice, which is outlined in the text book. If he passes this successfully, and his record in the shop has been satisfactory, he is granted a certificate of apprenticeship, and is given a bonus of $25, in addition to the percentage of his wages which has been held by the company. He is then given journeyman's wages, the rate depending upon his past record.

We are indebted to Mr. W. D. Robb, superintendent of motive power, and Mr. James Powell, chief draftsman, for information.



MECHANICAL DRAWING EXAMINATION. FIFTH YEAR APPRENTICES.

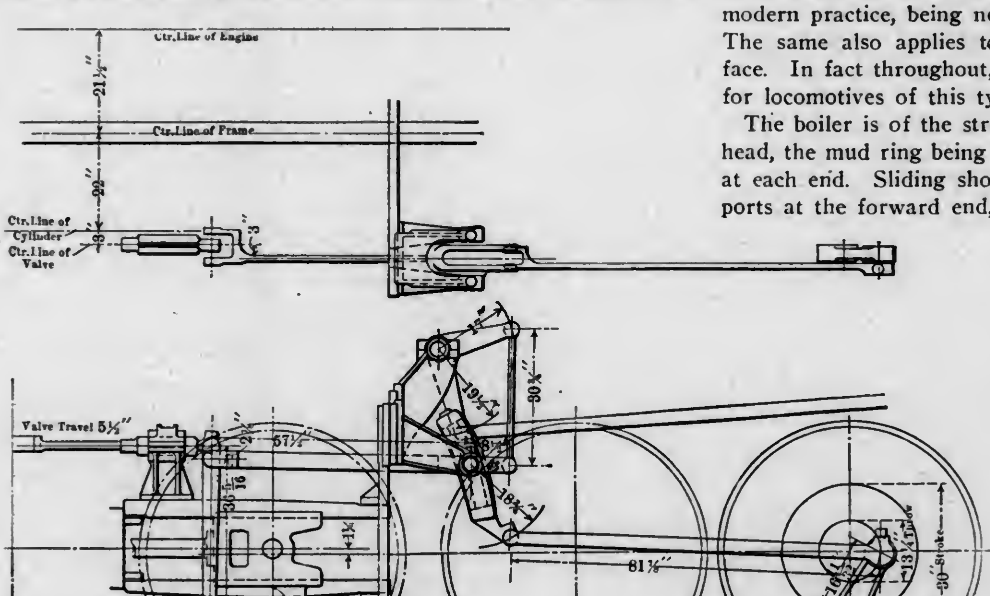
SIMPLE CONSOLIDATION LOCOMOTIVE.

CINCINNATI, NEW ORLEANS & TEXAS PACIFIC RAILWAY.

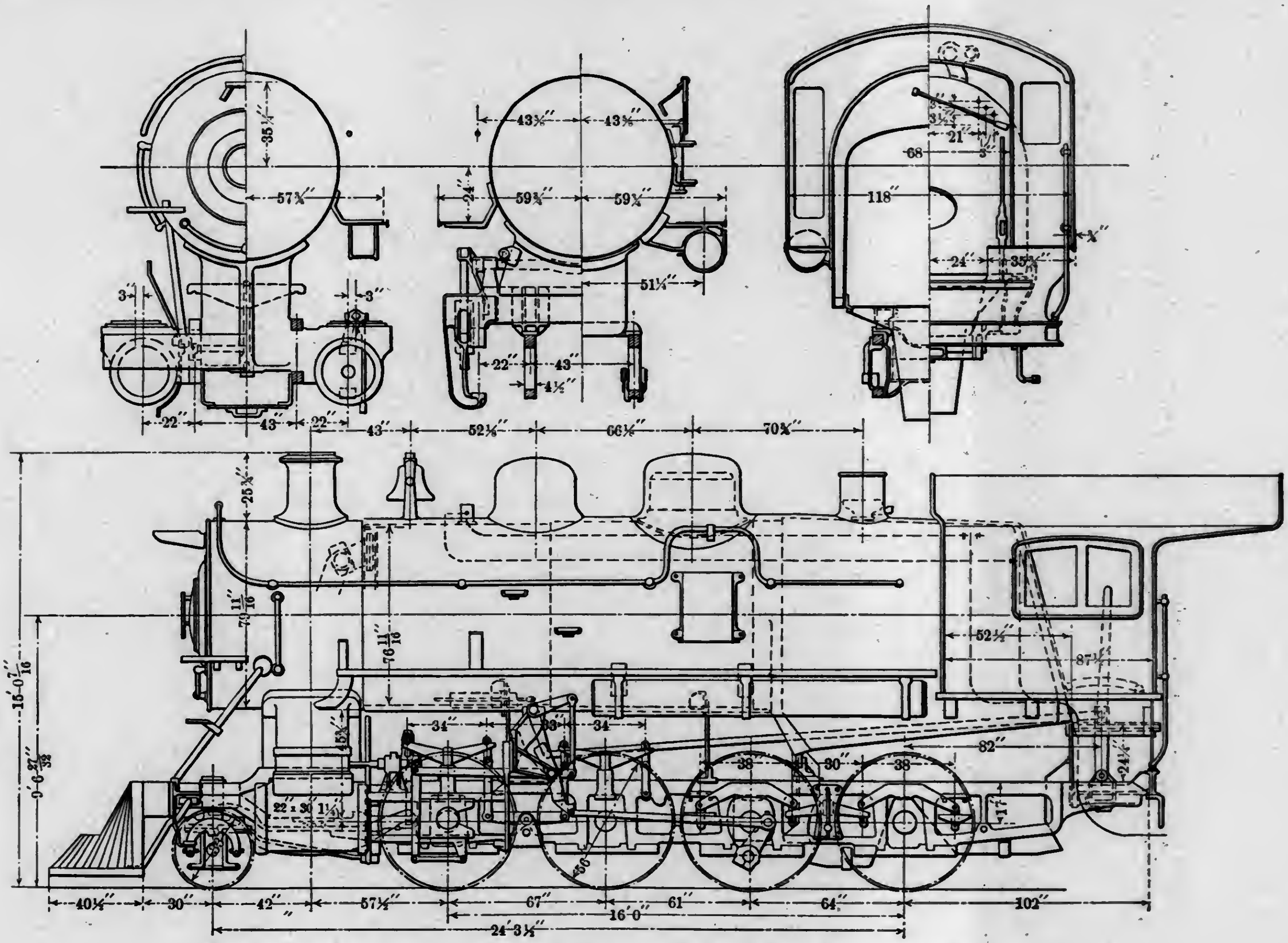
The Baldwin Locomotive Works have recently delivered 25 heavy consolidation locomotives to the Cincinnati, New Orleans & Texas Pacific Railway, which were built from prints furnished by the Railway Company and are known as class D9.

These locomotives have a tractive effort of 44,100 lbs., 56-in. drivers and are an excellent example of straightforward design for a very powerful freight locomotive. They are intended for service over the Cumberland Mountains, where the maximum grade is 60 ft. to the mile and will be rated at 1,000 tons over that division. A study of the ratios given in the following table will show the conservatism of the design throughout. The use of 56-in. drivers with 30-in. stroke is quite common for locomotives intended for slow speed heavy work and permits a speed of 15 miles per hour with a piston speed of approximately 450 ft. per minute. While with a slide valve there will probably be some wire drawing at this speed, there will be no difficulty from this cause at speeds of from 8 to 10 miles per hour. The ratios of heating surface to cylinder volume are a fair average of good modern practice, being neither unusually high or unusually low. The same also applies to ratios of grate area to heating surface. In fact throughout, the ratios fall upon the average curve for locomotives of this type.

The boiler is of the straight type with sloping throat and back head, the mud ring being inclined and supported on buckle plates at each end. Sliding shoes are also provided as additional supports at the forward end, these being carried on a steel casting, which serves as a frame brace. The boiler barrel is built up of two rings and measures 76 11/16 in. outside diameter at the front end. The longitudinal joints are butt jointed and sextuple riveted. The fire-box is radially stayed with two T-irons supporting the forward end of the crown sheet. The depth of the throat is about 20 in. and the mud ring is 4 in. wide at this point. The mud ring on the sides and back is but 3½ in. wide, which space, however, is increased to 6 in. at the crown sheet. Three hundred and thirty flexible staybolts have been used in the breakage zone of the fire-box. The boiler contains 403 2-in. tubes, so dis-



WALSCHAERT VALVE GEAR—C. N. O. & T. P. CONSOLIDATION LOCOMOTIVE.



SIMPLE CONSOLIDATION LOCOMOTIVE—CHICAGO, NEW ORLEANS AND TEXAS PACIFIC RAILWAY.

posed as to give approximately ¾-in. bridges on the back flue sheet. Two tubes, one on either side at about the center of the flue sheet, are replaced by stay tubes which consist of a wrought iron bar welded into the back end of the tube and tapered down to 1 in. in diameter, threaded and screwed into the back flue sheet, being riveted over in the same manner as a staybolt. In the front tube sheet these tubes are expanded and beaded. The total heating surface of the boiler is 3,226 sq. ft., of which 175 sq. ft., or 5.42 per cent., is in the fire-box.

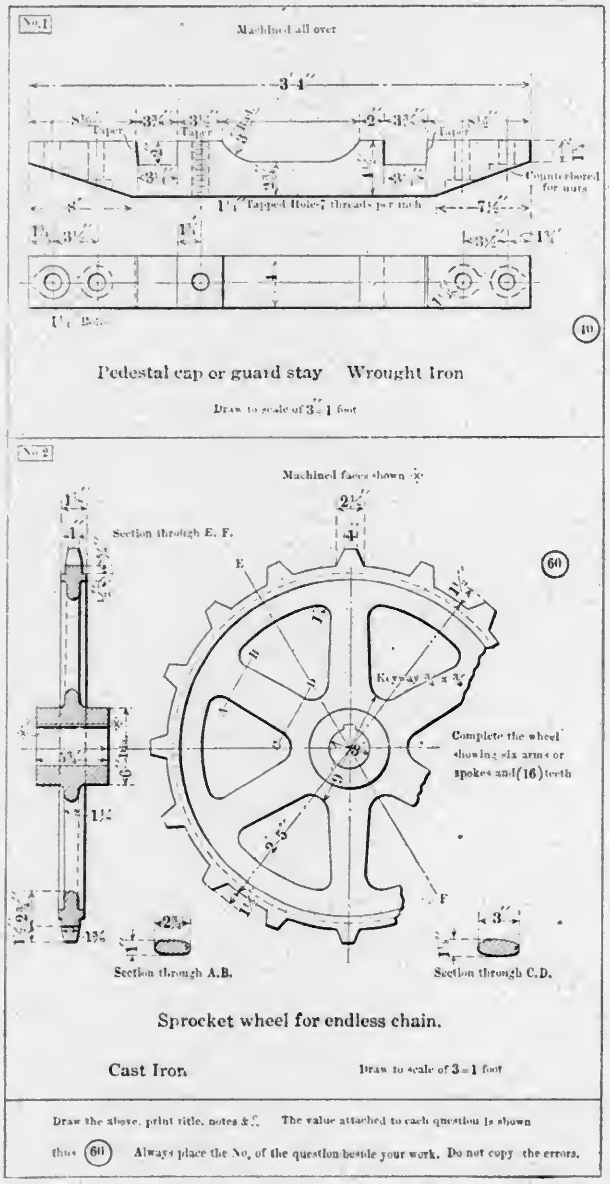
It will be noted in the illustration that both of the feed pipes are connected to a boiler check valve on top of the shell. This valve is known as the Phillips patent double boiler check and is manufactured by the Nathan Mfg. Co. It is fitted with a double series of check valves, one valve being inside the boiler shell for emergency purposes and two valves at the top of the casting, one serving each feed pipe. In addition to these there are two shut-off valves behind the check valve so that the latter can be removed and ground in while steam pressure is on the boiler. The feed water enters the boiler directly from the bottom of this attachment and thus is considerably heated by passing through the steam at the top of the boiler. There are no inside feed pipes.

The cylinders are equipped with balance slide valves, having 5½ in. travel, an outside lap of 1 in. and 3/16 in. constant lead. They are operated by the Walschaert type of valve gear, the construction and arrangement of which is shown in one of the illustrations. The link and reverse shaft bearings are bolted to the guide yoke and the radius bar is operated by a hanger connected to it back of the link. The valve stem is supported on a bracket bolted to the top guide, and is rectangular at its bearing point. The eccentric cranks are of cast steel, being split at the large end and clamped and bolted to the main pins. The reach rod connects directly to the downwardly extending arm on the reverse shaft.

lined above, it had been somewhat neglected, and it was found difficult to get a good class of apprentices and workmen. The difficulty of obtaining good apprentices almost immediately disappeared upon the establishment of the present system. Under the old system, when the entrance requirements were not so rigid, parents would take their boys out of school at 13 and have them work at some other shop for two years, and then have them start to work at 15 in the railroad shops. Now it is necessary for them to keep the boys at school longer in order that they may "make good" when they enter the service of the railroad. In addition to recruiting the force in the shops, and providing the company with a better grade of mechanics, a number of the boys have developed into first-class draftsmen, and have been found to be much more valuable to the company than the average draftsman, who has little or no shop experience.

Graduation.—At the end of his term the apprentice is required to take an examination in shop practice, which is outlined in the text book. If he passes this successfully, and his record in the shop has been satisfactory, he is granted a certificate of apprenticeship, and is given a bonus of $25, in addition to the percentage of his wages which has been held by the company. He is then given journeyman's wages, the rate depending upon his past record.

We are indebted to Mr. W. D. Robb, superintendent of motive power, and Mr. James Powell, chief draftsman, for information.



MECHANICAL DRAWING EXAMINATION. FIFTH YEAR APPRENTICES.

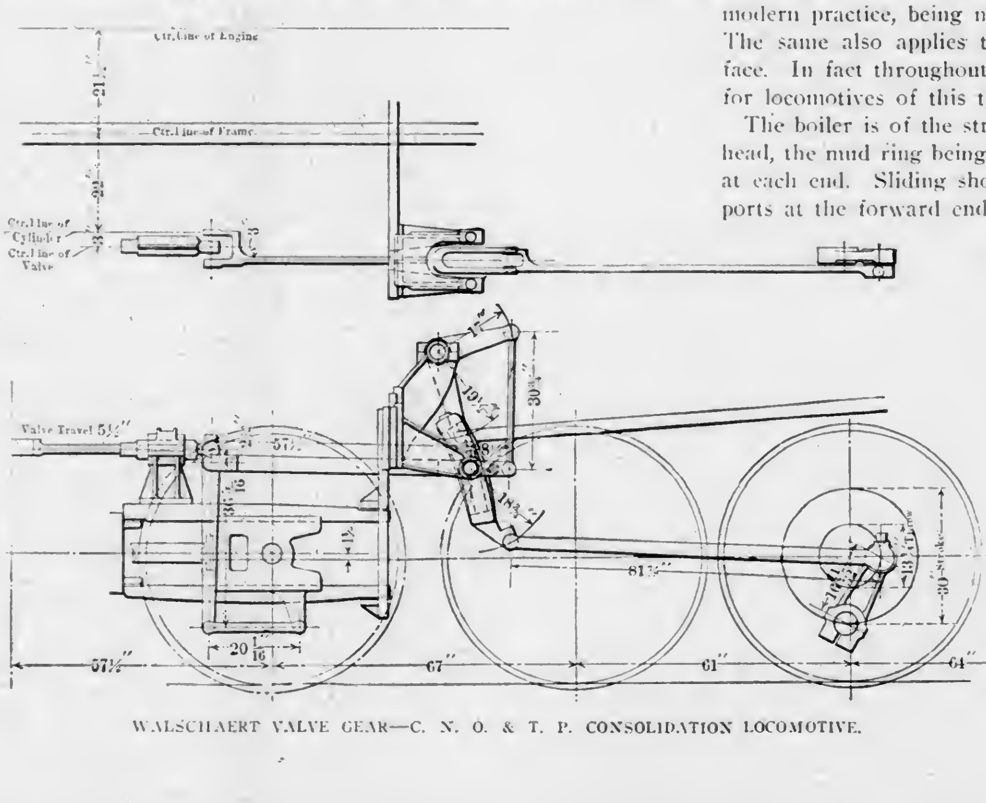
SIMPLE CONSOLIDATION LOCOMOTIVE.

CINCINNATI, NEW ORLEANS & TEXAS PACIFIC RAILWAY.

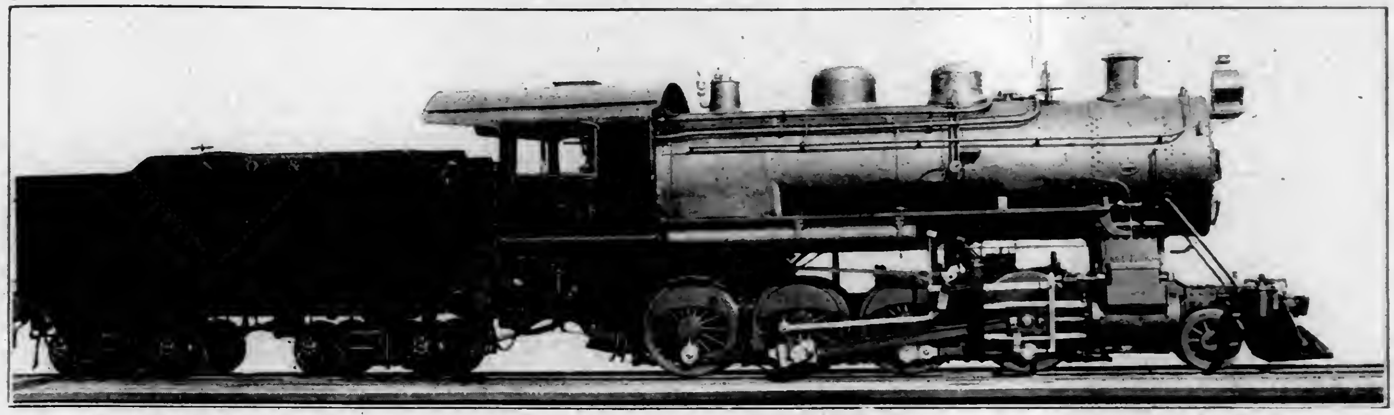
The Baldwin Locomotive Works have recently delivered 25 heavy consolidation locomotives to the Cincinnati, New Orleans & Texas Pacific Railway, which were built from prints furnished by the Railway Company and are known as class D9.

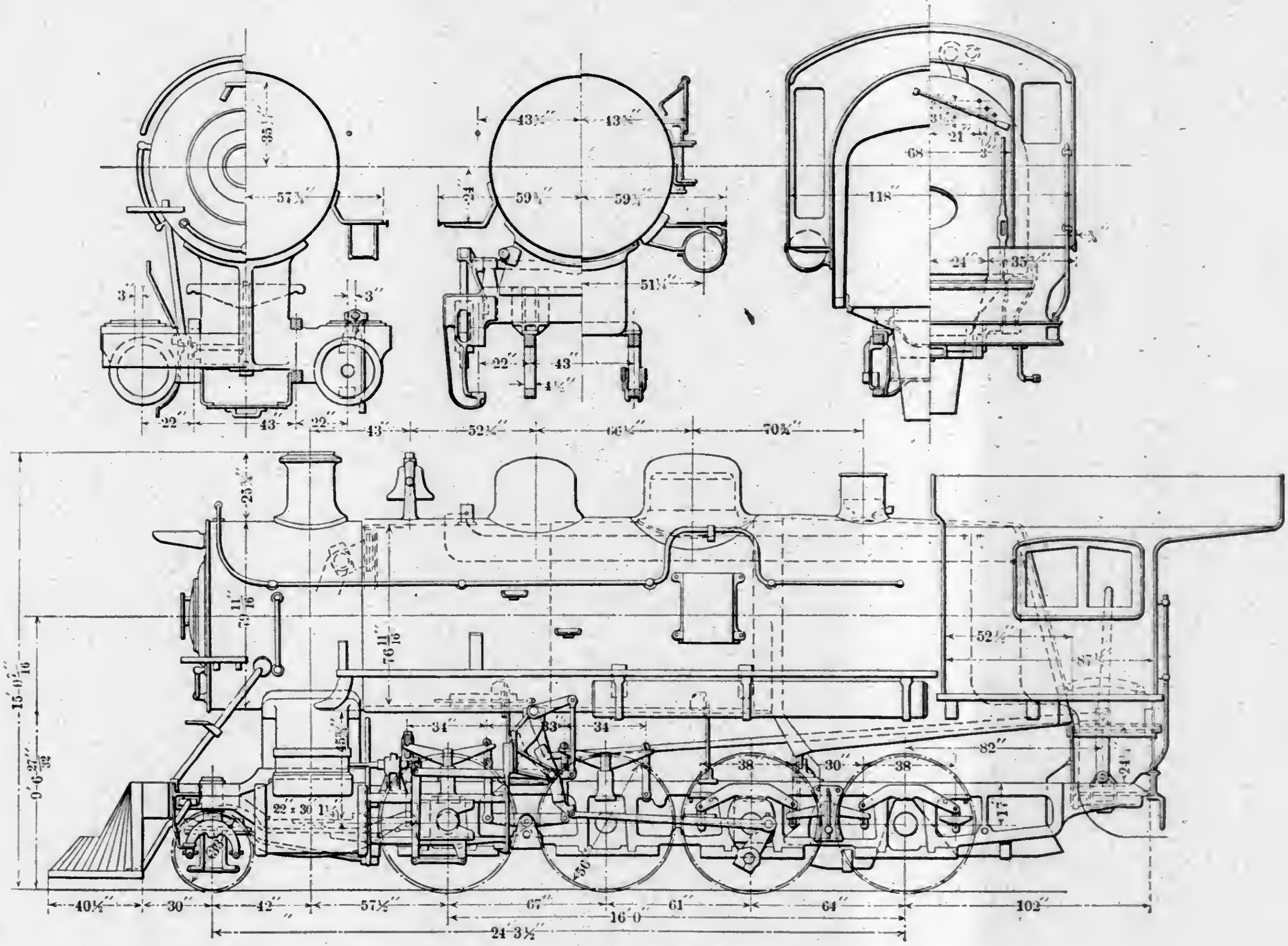
These locomotives have a tractive effort of 44,100 lbs., 56-in. drivers and are an excellent example of straightforward design for a very powerful freight locomotive. They are intended for service over the Cumberland Mountains, where the maximum grade is 60 ft. to the mile and will be rated at 1,000 tons over that division. A study of the ratios given in the following table will show the conservatism of the design throughout. The use of 56-in. drivers with 30-in. stroke is quite common for locomotives intended for slow speed heavy work and permits a speed of 15 miles per hour with a piston speed of approximately 450 ft. per minute. While with a slide valve there will probably be some wire drawing at this speed, there will be no difficulty from this cause at speeds of from 8 to 10 miles per hour. The ratios of heating surface to cylinder volume are a fair average of good modern practice, being neither unusually high or unusually low. The same also applies to ratios of grate area to heating surface. In fact throughout, the ratios fall upon the average curve for locomotives of this type.

The boiler is of the straight type with sloping throat and back head, the mud ring being inclined and supported on buckle plates at each end. Sliding shoes are also provided as additional supports at the forward end, these being carried on a steel casting, which serves as a frame brace. The boiler barrel is built up of two rings and measures 76 11/16 in. outside diameter at the front end. The longitudinal joints are butt jointed and sextuple riveted. The fire-box is radially stayed with two T-irons supporting the forward end of the crown sheet. The depth of the throat is about 20 in. and the mud ring is 4 in. wide at this point. The mud ring on the sides and back is but 3½ in. wide, which space, however, is increased to 6 in. at the crown sheet. Three hundred and thirty flexible staybolts have been used in the breakage zone of the fire-box. The boiler contains 403 2-in. tubes, so dis-



WALSCHAERT VALVE GEAR—C. N. O. & T. P. CONSOLIDATION LOCOMOTIVE.





SIMPLE CONSOLIDATION LOCOMOTIVE—CHICAGO, NEW ORLEANS AND TEXAS PACIFIC RAILWAY.

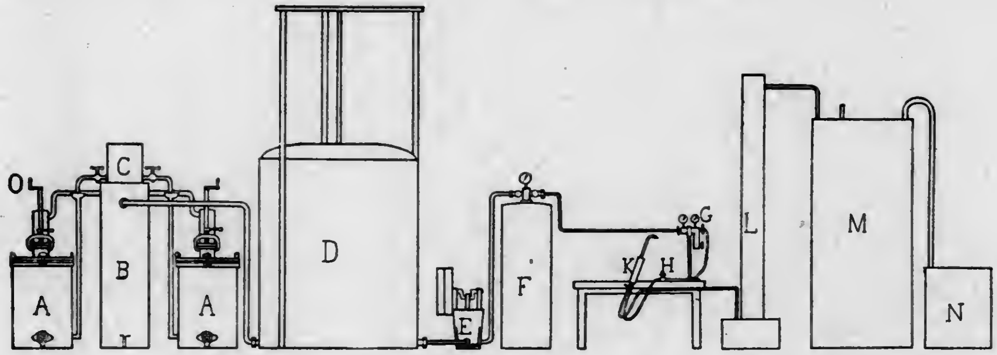
posed as to give approximately ¾-in. bridges on the back flue sheet. Two tubes, one on either side at about the center of the flue sheet, are replaced by stay tubes which consist of a wrought iron bar welded into the back end of the tube and tapered down to 1 in. in diameter, threaded and screwed into the back flue sheet, being riveted over in the same manner as a staybolt. In the front tube sheet these tubes are expanded and beaded. The total heating surface of the boiler is 3,226 sq. ft., of which 175 sq. ft., or 5.42 per cent., is in the fire-box.

It will be noted in the illustration that both of the feed pipes are connected to a boiler check valve on top of the shell. This valve is known as the Phillips patent double boiler check and is manufactured by the Nathan Mfg. Co. It is fitted with a double series of check valves, one valve being inside the boiler shell for emergency purposes and two valves at the top of the casting, one serving each feed pipe. In addition to these there are two shut-off valves behind the check valve so that the latter can be removed and ground in while steam pressure is on the boiler. The feed water enters the boiler directly from the bottom of this attachment and thus is considerably heated by passing through the steam at the top of the boiler. There are no inside feed pipes.

The cylinders are equipped with balance slide valves, having 5½ in. travel, an outside lap of 1 in. and 3/16 in. constant lead. They are operated by the Walschaert type of valve gear, the construction and arrangement of which is shown in one of the illustrations. The link and reverse shaft bearings are bolted to the guide yoke and the radius bar is operated by a hanger connected to it back of the link. The valve stem is supported on a bracket bolted to the top guide, and is rectangular at its bearing point. The eccentric cranks are of cast steel, being split at the large end and clamped and bolted to the main pins. The reach rod connects directly to the downwardly extending arm on the reverse shaft.

The frames are of cast steel with double front rails of wrought iron. Each rail is double keyed to the main frame. A large cast steel foot plate forms a stubstantial frame bracing at the rear end and is assisted by two pieces of channel iron, which constitute the back bumping plate. The general features of construction are clearly shown in the illustrations and the general dimensions, weights and ratios are shown in the following table:

GENERAL DATA.	
Gauge	4 ft. 8½ in.
Service	Freight
Fuel	Bit. Coal
Tractive effort	44,100 lbs.
Weight in working order	203,600 lbs.
Weight on drivers	182,000 lbs.
Weight on leading truck	21,600 lbs.
Weight of engine and tender in working order	350,000 lbs.
Wheel base, driving	16 ft.
Wheel base, total	24 ft. 3½ in.
Wheel base, engine and tender	56 ft. 7¼ in.
RATIOS.	
Weight on drivers ÷ tractive effort	4.13
Total weight ÷ tractive effort	4.61
Tractive effort x diam. drivers ÷ heating surface	768.00
Total heating surface ÷ grate area	59.80
Firebox heating surface ÷ total heating surface, per cent	5.42
Weight on drivers ÷ total heating surface	56.40
Total weight ÷ total heating surface	63.00
Volume both cylinders, cu. ft	13.20
Total heating surface ÷ vol. cylinders	244.00
Grate area ÷ vol. cylinders	4.10
CYLINDERS.	
Kind	Simple
Diameter and stroke	22 x 30 in.
VALVES.	
Kind	Bal. Slide
Greatest travel	5½ in.
Outside lap	1 in.
Lead, constant	3/16 in.
WHEELS.	
Driving, diameter over tires	56 in.
Driving, thickness of tires	3 in.
Driving journals, main, diameter and length	10 x 12 in.
Driving journals, others, diameter and length	9 x 12 in.
Engine truck wheels, diameter	33 in.
Engine truck, journals	5½ x 10 in.
BOILER.	
Style	Straight
Working pressure	200 lbs.
Outside diameter of first ring	76 11/16 in.
Firebox, length and width	108 x 71¾ in.
Firebox plates, thickness	⅜ & ½ in.
Firebox, water space	F.-4⅛, S. & B.-3½ in.
Tubes, number and outside diameter	403—2 in.
Tubes, length	14 ft. 6½ in.
Heating surface, tubes	3,051 sq. ft.
Heating surface, firebox	175 sq. ft.
Heating surface, total	3,226 sq. ft.
Grate area	54 sq. ft.
Smokestack, height above rail	180 7/16 in.
Centre of boiler above rail	114⅞ in.
TENDER.	
Wheels, diameter	33 in.
Journals, diameter and length	5½ x 10 in.
Water capacity	7,500 gals.
Coal capacity	12½ tons.



ARRANGEMENT OF OXYGEN-ACETYLENE PLANT.

(A to H, oxygen apparatus; L to N, acetylene apparatus; A and A¹, oxygen generators; B, cleaning tower; C, catalyser vessel; O, agitator; D, gasometer; E, compressor; F, pressure-reservoir; G, pressure-regulator; H, cock; K, blowpipe; L, safety valve; M, gasometer for constant pressure; N, acetylene generator.)

OXY-ACETYLENE METHODS OF WELDING AND CUTTING METALS.

It has been customary for a number of years to weld the butt joints of locomotive boiler shells at the ends and other points where they can be reinforced to withstand the pressure, but the idea of welding the joint for its full length, and of obtaining a strength at this point nearly equivalent to the remainder of the sheet and greater than the usual riveted joint, is altogether a new idea on American railways. Such construction, however, has recently been made possible by the perfection of a comparatively simple apparatus for generating pure acetylene gas and pure oxygen and bringing them together in a blow pipe flame, which has a temperature capable of fusing practically any metal. The same flame can also be used for cutting sheets of steel or other material, performing a perfect job with no more waste of metal than would occur with a saw and with the great advantage that sections of irregular shape can be cut as easily as straight.

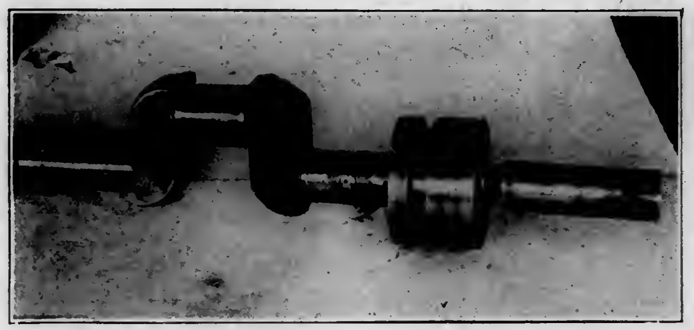
Acetylene, the properties and generation of which are generally understood, is a gas very rich in carbon, containing as it does about 92.3 per cent., and it is possible to obtain a temperature higher than that of the oxy-hydrogen blow pipe flame (3,600 degs. F.) by its combustion with air in a Bunson burner. When, however, acetylene gas is burned with oxygen instead of air there is produced the hottest flame known, as a product of combustion, which has a temperature of 6,300 degs. F. or very nearly that of an electric arc. By the proper proportions of the two gases this flame can be made absolutely neutral in its action and have neither an oxidizing or carburetting tendency. These facts have been known for a long time, but the inconvenience and cost of obtaining pure oxygen in a commercial manner has prevented the practical use of the knowledge on any large scale.

The comparative recent discovery of a powder, or chemical, called "Euprite," which acts in much the same way as does calcium carbide in the production of acetylene gas and permits the generation of chemically pure oxygen in apparatus similar to the acetylene gas generator, has made it possible to commercially utilize this very high temperature at a comparatively low cost.

One of the illustrations shows a diagrammatical view of the apparatus required for this purpose. The section at the left of the blow pipe (K) is for the generation of the oxygen, and the section to the right is for acetylene gas. Both gases are brought to the blow pipe under pressure, there being automatic pressure regulators and stop valves provided so that the amount and pressure of either gas can be varied at will. The blow pipe is of a size corresponding to the work on which it is to be employed, and the gases should arrive at the nozzle at slightly over 2 lbs. pleasure, which will give an exit speed and flow of the gas through the pipes sufficient to counteract any back burning of the mixture before reaching the end of the blow pipe. Metallic gauzes are also provided to prevent the flame throwing back, and it is said that the danger of accident or explosion with the apparatus is practically eliminated, and that an inexperienced operator is able to control it without danger.

In welding two pieces of any considerable thickness the edges are beveled so that it is possible to heat to the bottom of the weld. The blow pipe flame is directed into the opening until the two edges are fused, and at the same time a rod of the same metal, which is held in the flames, is fused and fills the space between the sheets in much the same manner as in soldering. This work being carefully done, results in a joint which is practically a part of the sheet, and outside of the fact that it has not been possible to work the metal in a joint and thus increase its strength, gives a connection which is equal in strength to any part

THE BROKEN CRANK SHAFT.



READY FOR WELDING.

BEING WELDED.

READY FOR THE MACHINE.

of the sheet. In practice, by building up the metal on top of the joint, and thus giving a greater sectional area, the joint is made nearly equal in strength to the remainder of the sheet.

The same method can be used in repairing boiler or firebox sheets which have cracked along the edges or at staybolts, or been corroded away at certain points, and the sheets restored to their full strength by the building up with new material to any extent desired. Repairs of this nature can be safely considered as an integral part of the sheet rather than as a patch.

The illustrations show a broken crank shaft and the different processes followed in welding the two sections together, making it practically as good as new and at a very slight expense compared to the cost of constructing a new shaft. The work shown in the illustration was performed by the Worcester Pressed Steel Company, which has a plant of this kind in operation.

For cutting sheets the flame, by change in pressure, is somewhat elongated and given somewhat of an oxidizing effect and simply burns a narrow cut through the plate following any desired contour. The edges of the sheet are smooth and even, and plates up to 5 in. in thickness have been cut in this manner.

This process is not only adapted for making tanks, boilers, tubing and pipe joints and angles, and for replacing brazing and riveting in many instances, but it also can be used effectively to weld steel castings. Many defective castings have been saved in the foundry by the filling in of the blow holes with new metal or welding together smaller sections of the castings which have been broken apart. It will also, no doubt, prove to be a great time-saver by permitting small leaks or breaks to be repaired without removing the parts from the locomotive.

This system of welding is known as the auto-genous welding and the process and apparatus is controlled by the Industrial Oxygen Company, Hanover Bank Building, 11 Pine Street, New York City.

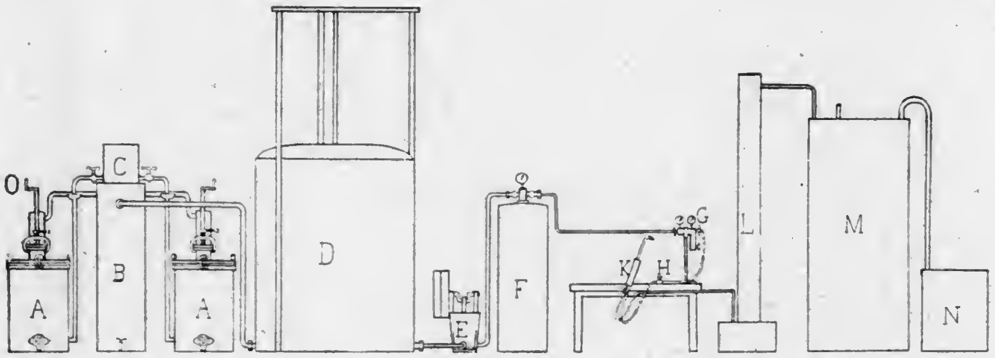
SHOP LIGHTING.

To furnish the most up-to-date machinery and tools, and pay the present high prices for labor, and then to handicap the workmen by insufficient, or improperly placed lights, is a fallacy too patent to require argument; and still such cases are by no means uncommon. It will perhaps add to the impressiveness of this statement to make use of a few computations. Let us take as a basis the electric light, which is admittedly the most expensive form of artificial illumination, and let us say that the current is purchased at the retail price of 10 cents per unit (kilowatt hour). A 16-candle-power lamp can be burned 18 hours by the use of one unit, that is, at a cost of 10 cents, or 55 mills per hour. The ordinary workman, receiving, say, 20 cents per hour, would only have to lose a trifle over a minute and a half out of an hour to represent a loss equal to the cost of the light; while a skilled workman, receiving, say, 50 cents per hour, would have to lose only a little over half a minute ever hour to represent a similar loss. In other words, the ordinary workman losing 13 minutes in a day of 8 hours, or the skilled workman 5 minutes in the same time, would equal the cost of running the lamp for the entire working day. But instead of electricity costing 10 cents per unit, it may be generated in large works, where power is already at hand, as well as the fixed charges of superintendence, etc., as low as 2 cents per unit, which would reduce the above figures to one-fifth; that is, the average workman would have to lose only about 2½ minutes in an entire working day of 8 hours, and the skilled workman but a little over a minute, to represent the cost of the lamp for a day. But the loss in wages is not all; loss in time of the operative represents a loss from the non-use of the machine. And again, besides there being a reduction in the amount of product, there is often a reduction in quality also, which is far more serious than the reduction in quantity.—*The Illuminating Engineer.*

PRODUCER GAS ENGINE PLANT MOST ECONOMICAL.—Personally, I believe that a gas-engine plant, making its own producer gas, will operate at least as reliably as a steam plant and will use from 30 to 60 per cent. less fuel, depending principally on the size of the steam plant. The drawbacks to the gas plant are, in my mind, the first cost, approximating $200 per kilowatt when rated so as to have a 33⅓ per cent. overload capacity, and the small size of units—the largest gas engine now built being only of about 3,000 kilowatt capacity.—*Paul Winsor before the Amer. Street and Interurban Ry. Eng. Assoc.*

The frames are of cast steel with double front rails of wrought iron. Each rail is double keyed to the main frame. A large cast steel foot plate forms a substantial frame bracing at the rear end and is assisted by two pieces of channel iron, which constitute the back bumping plate. The general features of construction are clearly shown in the illustrations and the general dimensions, weights and ratios are shown in the following table:

GENERAL DATA.	
Gauge	4 ft. 8½ in.
Service	Freight
Fuel	Bit. Coal
Tractive effort	44,100 lbs.
Weight in working order	203,600 lbs.
Weight on drivers	182,000 lbs.
Weight on leading truck	21,600 lbs.
Weight of engine and tender in working order	350,000 lbs.
Wheel base, driving	16 ft.
Wheel base, total	24 ft. 3½ in.
Wheel base, engine and tender	56 ft. 7¼ in.
RATIOS.	
Weight on drivers ÷ tractive effort	4.13
Total weight ÷ tractive effort	4.61
Tractive effort x diam. drivers ÷ heating surface	768.00
Total heating surface ÷ grate area	59.80
Firebox heating surface ÷ total heating surface, per cent	5.42
Weight on drivers ÷ total heating surface	56.40
Total weight ÷ total heating surface	63.00
Volume both cylinders, cu. ft	13.20
Total heating surface ÷ vol. cylinders	244.00
Grate area ÷ vol. cylinders	4.10
CYLINDERS.	
Kind	Simple
Diameter and stroke	22 x 30 in.
VALVES.	
Kind	Bal. Slide
Greatest travel	5½ in.
Outside lap	1 in.
Lead, constant	3/16 in.
WHEELS.	
Driving, diameter over tires	56 in.
Driving, thickness of tires	3 in.
Driving journals, main, diameter and length	10 x 12 in.
Driving journals, others, diameter and length	9 x 12 in.
Engine truck wheels, diameter	33 in.
Engine truck, journals	5½ x 10 in.
BOILER.	
Style	Straight
Working pressure	200 lbs.
Outside diameter of first ring	76 11/16 in.
Firebox, length and width	108 x 71¾ in.
Firebox plates, thickness	⅜ & ½ in.
Firebox, water space	F.-4½, S. & B.-3½ in.
Tubes, number and outside diameter	403—2 in.
Tubes, length	14 ft. 6½ in.
Heating surface, tubes	3,051 sq. ft.
Heating surface, firebox	175 sq. ft.
Heating surface, total	3,226 sq. ft.
Grate area	54 sq. ft.
Smokestack, height above rail	180 7/16 in.
Centre of boiler above rail	114⅞ in.
TENDER.	
Wheels, diameter	33 in.
Journals, diameter and length	5½ x 10 in.
Water capacity	7,500 gals.
Coal capacity	12½ tons.



ARRANGEMENT OF OXYGEN-ACETYLENE PLANT.

A to H oxygen apparatus; L to N, acetylene apparatus; A and A', oxygen generators; B, cleaning tower; C, catalyser vessel; O, agitator; D, gasometer; E, compressor; F, pressure reservoir; G, pressure regulator; H, cock; K, blowpipe; L, safety valve; M, gasometer for constant pressure; N, acetylene generator.

OXY-ACETYLENE METHODS OF WELDING AND CUTTING METALS.

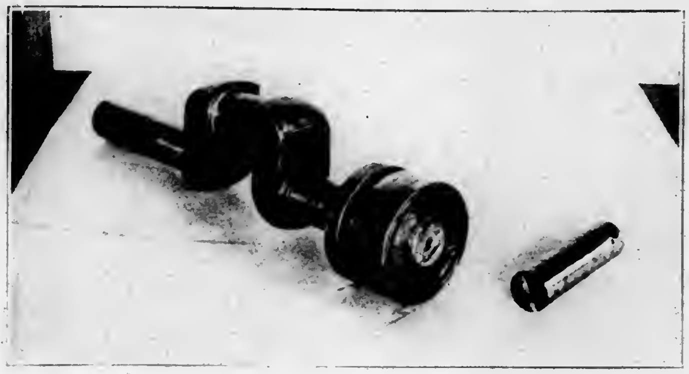
It has been customary for a number of years to weld the butt joints of locomotive boiler shells at the ends and other points where they can be reinforced to withstand the pressure, but the idea of welding the joint for its full length, and of obtaining a strength at this point nearly equivalent to the remainder of the sheet and greater than the usual riveted joint, is altogether a new idea on American railways. Such construction, however, has recently been made possible by the perfection of a comparatively simple apparatus for generating pure acetylene gas and pure oxygen and bringing them together in a blow pipe flame, which has a temperature capable of fusing practically any metal. The same flame can also be used for cutting sheets of steel or other material, performing a perfect job with no more waste of metal than would occur with a saw and with the great advantage that sections of irregular shape can be cut as easily as straight.

Acetylene, the properties and generation of which are generally understood, is a gas very rich in carbon, containing as it does about 92.3 per cent., and it is possible to obtain a temperature higher than that of the oxy-hydrogen blow pipe flame (3,600 degs. F.) by its combustion with air in a Bunsen burner. When, however, acetylene gas is burned with oxygen instead of air there is produced the hottest flame known, as a product of combustion, which has a temperature of 6,300 degs. F. or very nearly that of an electric arc. By the proper proportions of the two gases this flame can be made absolutely neutral in its action and have neither an oxidizing or carburetting tendency. These facts have been known for a long time, but the inconvenience and cost of obtaining pure oxygen in a commercial manner has prevented the practical use of the knowledge on any large scale.

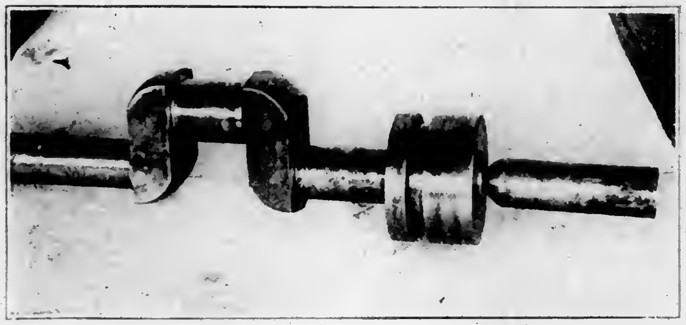
The comparative recent discovery of a powder, or chemical, called "Euprite," which acts in much the same way as does calcium carbide in the production of acetylene gas and permits the generation of chemically pure oxygen in apparatus similar to the acetylene gas generator, has made it possible to commercially utilize this very high temperature at a comparatively low cost.

One of the illustrations shows a diagrammatical view of the apparatus required for this purpose. The section at the left of the blow pipe (K) is for the generation of the oxygen, and the section to the right is for acetylene gas. Both gases are brought to the blow pipe under pressure, there being automatic pressure regulators and stop valves provided so that the amount and pressure of either gas can be varied at will. The blow pipe is of a size corresponding to the work on which it is to be employed, and the gases should arrive at the nozzle at slightly over 2 lbs. pleasure, which will give an exit speed and flow of the gas through the pipes sufficient to counteract any back burning of the mixture before reaching the end of the blow pipe. Metallic gauzes are also provided to prevent the flame throwing back, and it is said that the danger of accident or explosion with the apparatus is practically eliminated, and that an inexperienced operator is able to control it without danger.

In welding two pieces of any considerable thickness the edges are beveled so that it is possible to heat to the bottom of the weld. The blow pipe flame is directed into the opening until the two edges are fused, and at the same time a rod of the same metal, which is held in the flames, is fused and fills the space between the sheets in much the same manner as in soldering. This work being carefully done, results in a joint which is practically a part of the sheet, and outside of the fact that it has not been possible to work the metal in a joint and thus increase its strength, gives a connection which is equal in strength to any part



THE BROKEN CRANK SHAFT.



READY FOR WELDING.

BEING WELDED.

READY FOR THE MACHINE.

of the sheet. In practice, by building up the metal on top of the joint, and thus giving a greater sectional area, the joint is made nearly equal in strength to the remainder of the sheet.

The same method can be used in repairing boiler or firebox sheets which have cracked along the edges or at staybolts, or been corroded away at certain points, and the sheets restored to their full strength by the building up with new material to any extent desired. Repairs of this nature can be safely considered as an integral part of the sheet rather than as a patch.

The illustrations show a broken crank shaft and the different processes followed in welding the two sections together, making it practically as good as new and at a very slight expense compared to the cost of constructing a new shaft. The work shown in the illustration was performed by the Worcester Pressed Steel Company, which has a plant of this kind in operation.

For cutting sheets the flame, by change in pressure, is somewhat elongated and given somewhat of an oxidizing effect and simply burns a narrow cut through the plate following any desired contour. The edges of the sheet are smooth and even, and plates up to 5 in. in thickness have been cut in this manner.

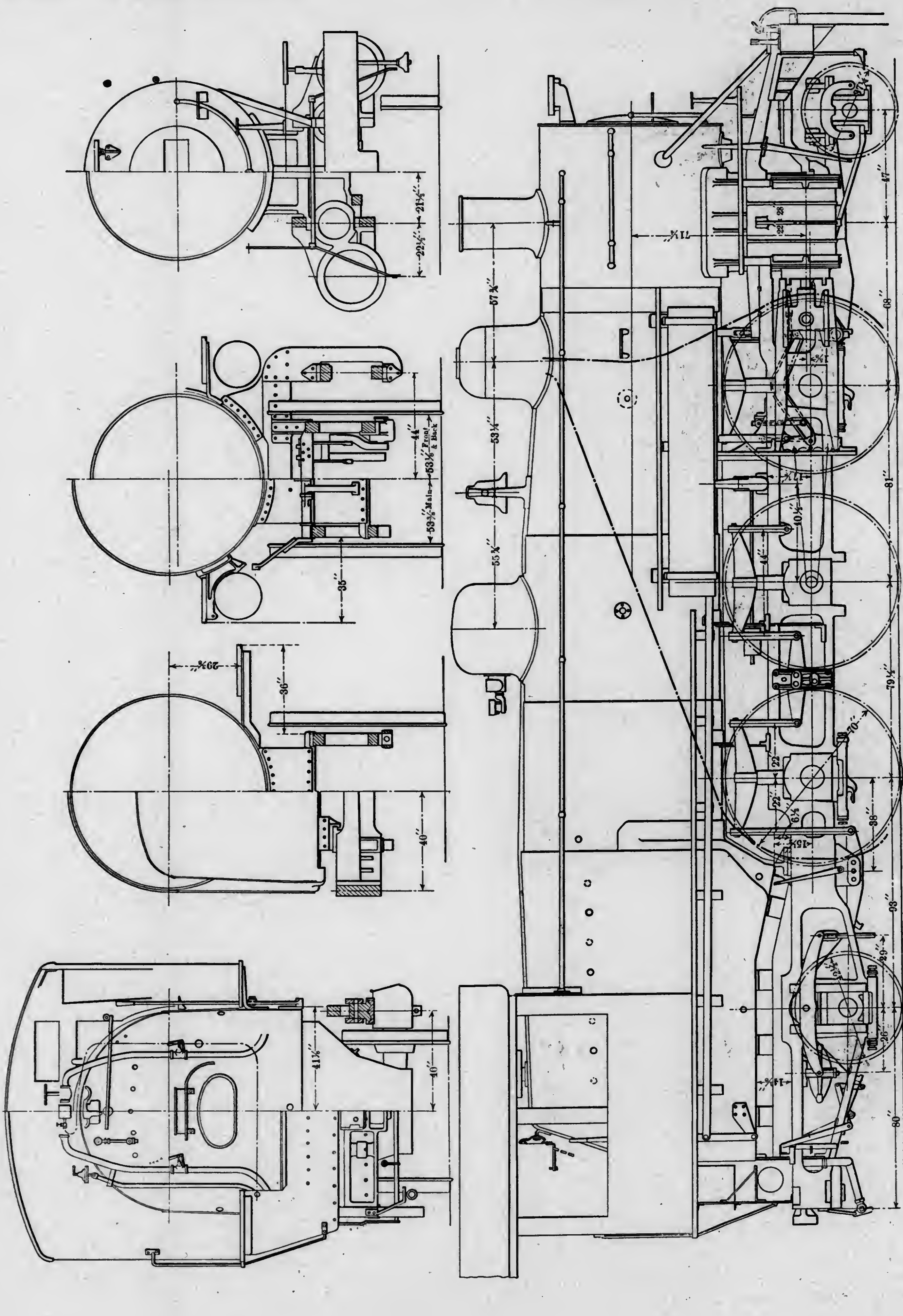
This process is not only adapted for making tanks, boilers, tubing and pipe joints and angles, and for replacing brazing and riveting in many instances, but it also can be used effectively to weld steel castings. Many defective castings have been saved in the foundry by the filling in of the blow holes with new metal or welding together smaller sections of the castings which have been broken apart. It will also, no doubt, prove to be a great time-saver by permitting small leaks or breaks to be repaired without removing the parts from the locomotive.

This system of welding is known as the auto-genous welding and the process and apparatus is controlled by the Industrial Oxygen Company, Hanover Bank Building, 11 Pine Street, New York City.

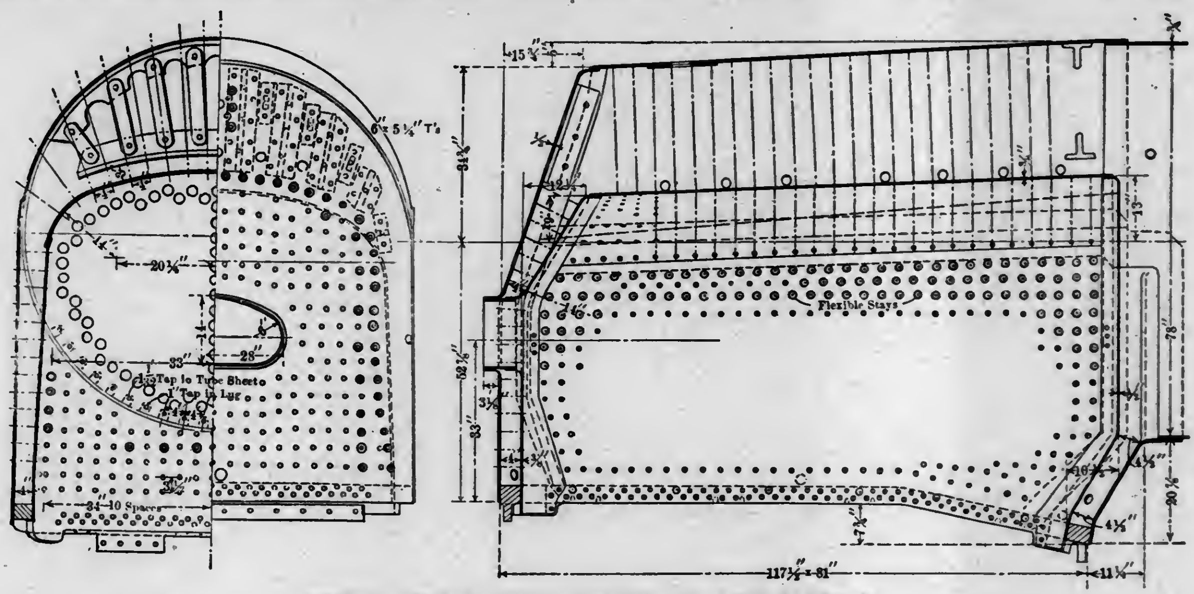
SHOP LIGHTING.

To furnish the most up-to-date machinery and tools, and pay the present high prices for labor, and then to handicap the workmen by insufficient, or improperly placed lights, is a fallacy too patent to require argument; and still such cases are by no means uncommon. It will perhaps add to the impressiveness of this statement to make use of a few computations. Let us take as a basis the electric light, which is admittedly the most expensive form of artificial illumination, and let us say that the current is purchased at the retail price of 10 cents per unit (kilowatt hour). A 16-candle-power lamp can be burned 18 hours by the use of one unit, that is, at a cost of 10 cents, or 55 mills per hour. The ordinary workman, receiving, say, 20 cents per hour, would only have to lose a trifle over a minute and a half out of an hour to represent a loss equal to the cost of the light; while a skilled workman, receiving, say, 50 cents per hour, would have to lose only a little over half a minute ever hour to represent a similar loss. In other words, the ordinary workman losing 13 minutes in a day of 8 hours, or the skilled workman 5 minutes in the same time, would equal the cost of running the lamp for the entire working day. But instead of electricity costing 10 cents per unit, it may be generated in large works, where power is already at hand, as well as the fixed charges of superintendence, etc., as low as 2 cents per unit, which would reduce the above figures to one-fifth; that is, the average workman would have to lose only about 2½ minutes in an entire working day of 8 hours, and the skilled workman but a little over a minute, to represent the cost of the lamp for a day. But the loss in wages is not all; loss in time of the operative represents a loss from the non-use of the machine. And again, besides there being a reduction in the amount of product, there is often a reduction in quality also, which is far more serious than the reduction in quantity.—*The Illuminating Engineer.*

PRODUCER GAS ENGINE PLANT MOST ECONOMICAL.—Personally, I believe that a gas-engine plant, making its own producer gas, will operate at least as reliably as a steam plant and will use from 30 to 60 per cent. less fuel, depending principally on the size of the steam plant. The drawbacks to the gas plant are, in my mind, the first cost, approximating $200 per kilowatt when rated so as to have a 33⅓ per cent. overload capacity, and the small size of units—the largest gas engine now built being only of about 3,000 kilowatt capacity.—*Paul Winsor before the Amer. Street and Interurban Ry. Eng. Assoc.*



PRAIRIE TYPE LOCOMOTIVES FOR FREIGHT SERVICE—WABASH RAILROAD.



FIREBOX, PRAIRIE TYPE LOCOMOTIVE—WABASH RAILROAD.

SIMPLE PRAIRIE TYPE LOCOMOTIVES.

WABASH RAILROAD.

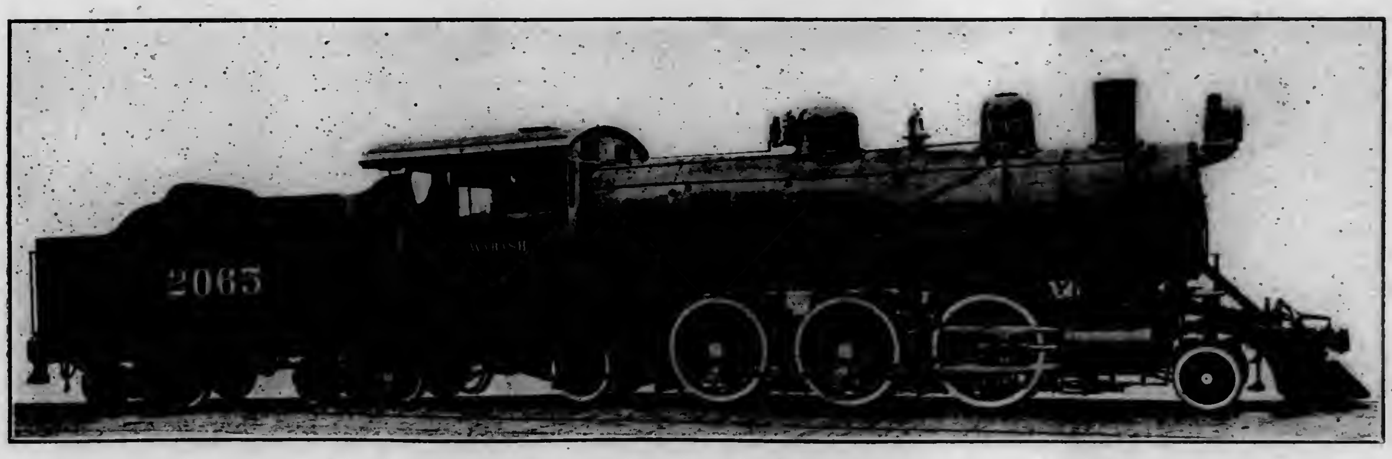
The American Locomotive Company is delivering an order of 60 Prairie type locomotives to the Wabash Railroad, of which 30 are fitted with 70-in. drivers, and intended for high-speed freight service, and 30 with 64-in. drivers for low speed freight service. In all other respects, except the diameter of the front truck wheels, the two classes are alike. The high speed engines have a tractive effort of 32,900 lbs., and the low speed, 36,000 lbs.

This design is very similar to, and in many respects identical with locomotives of the same type in service on the Chicago, Burlington & Quincy Railway, which were illustrated in this journal in August, 1906, page 300. The Burlington engines, however, by virtue of higher steam pressure and 1-in. smaller drivers give a higher tractive effort and are also somewhat heavier both in total weight and weight on drivers.

The boiler is of the extended wagon top type, 70 in. outside diameter at the front flue sheet and 79½ in. at the connection to the fire-box. The front flue sheet is secured in a ring of 1-in. plate to the interior of which is also fastened the front barrel sheet. The ⅝-in. smoke box sheet is riveted to the outside of this ring. The flue sheet is set 31 in. from the center line of the stack and 71½ in. from the forward end of the smoke-box. The flues, of which there are 301 2¼-in., are 19 ft. long and give a heating surface of 3,368.5 sq. ft. The fire-box, as will be seen in the illustration, is of the radial stay type with one T-iron sling stay support at the front end. Flexible staybolts are used in the breakage zones along the top and corners of the side sheets and in the throat sheet. The back head is vertical to the top of the fire door, from which point it slopes inward quite sharply. The water leg is of the same width, 4 in., from the mud ring up to the bend in the head, from which point it spreads to 9 in. at the connection to the crown sheet. The water space in the throat is 4½ in. in width at all points. The single fire door measures 14 x 28 in. Two non-lifting injectors, feeding to check valves in the usual location, are used.

The boiler ratios are liberal, there being 65½ sq. ft. of heating surface to one square foot of grate area and 288 square feet to one cubic foot of cylinder volume. There is one square foot of heating surface to 42½ lbs. weight on drivers.

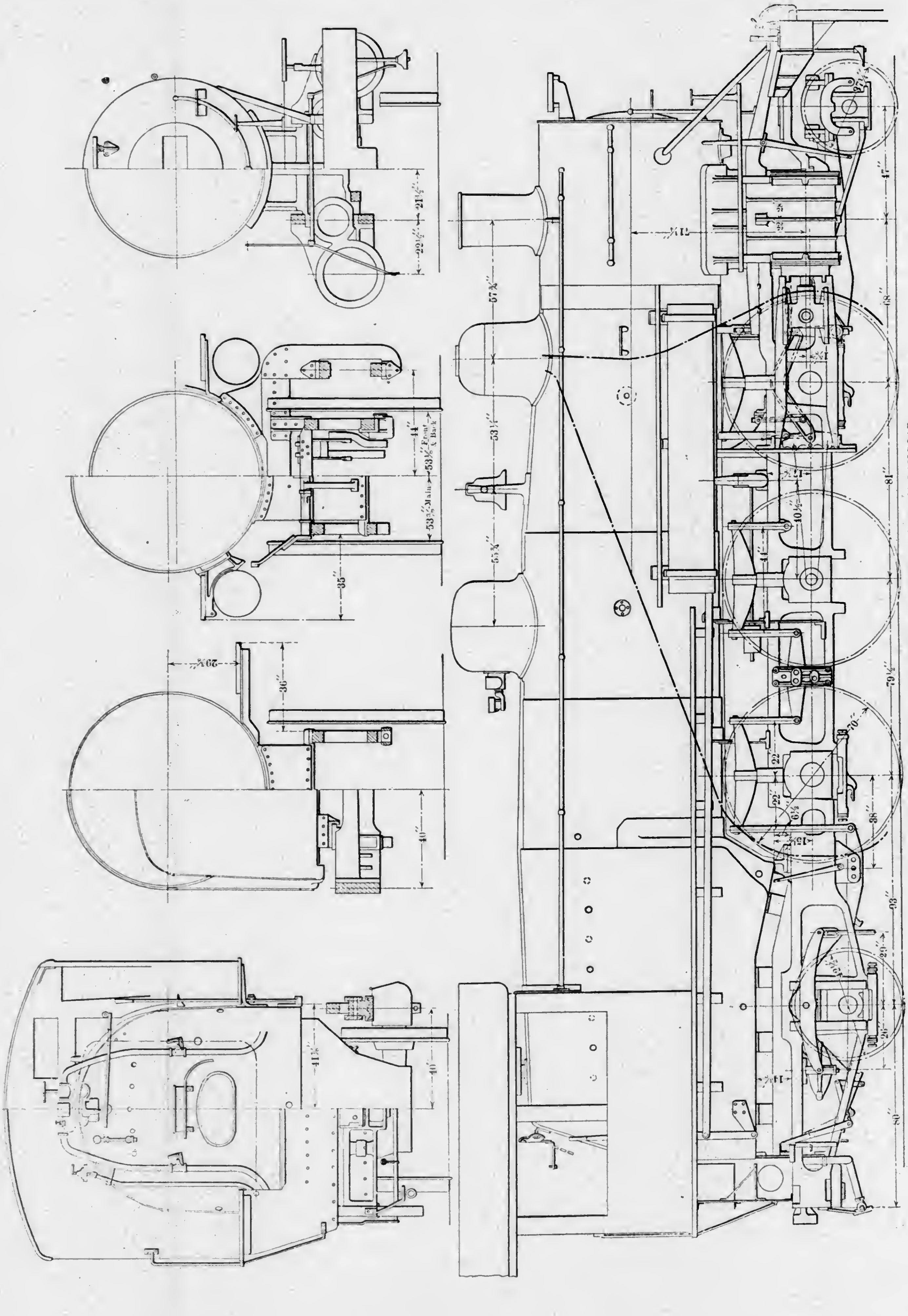
The 22 x 28-in. cylinders are served by 12-in. piston valves placed inside of the cylinders on a line with the frames. The Stephenson type of valve gear is employed, the eccentrics being on the second or main axle and the motion is transferred from the link through a transmission bar over the front axle. This bar is supported by a double hanger at its rear end and connects at the forward end to a rocker arm supported from a bearing secured below the bottom frame rail. The valve stem connection is made through a link pivoted to the rocker arm above the transmission bar connection.



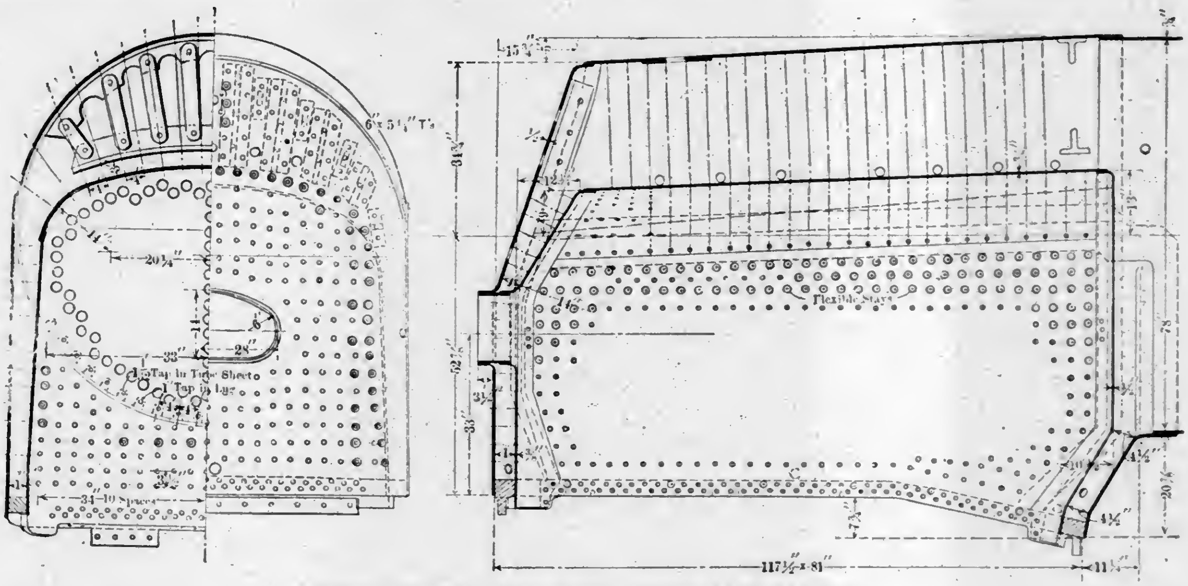
PRAIRIE TYPE FREIGHT LOCOMOTIVE—WABASH RAILROAD.

The same design of trailer truck frame that has been used on the Burlington for many years is found on these engines. This consists of a heavy cast steel cross bar forming a connection between the main frames, set at 43-in. centers, and the trailer truck frames set at 80-in. centers. The trailing wheels have outside journals, the equalizer resting on top of the journal box, as shown in the illustration.

The general dimensions, weights and ratios are given in the following table:



PRAIRIE TYPE LOCOMOTIVES FOR FREIGHT SERVICE—WABASH RAILROAD.



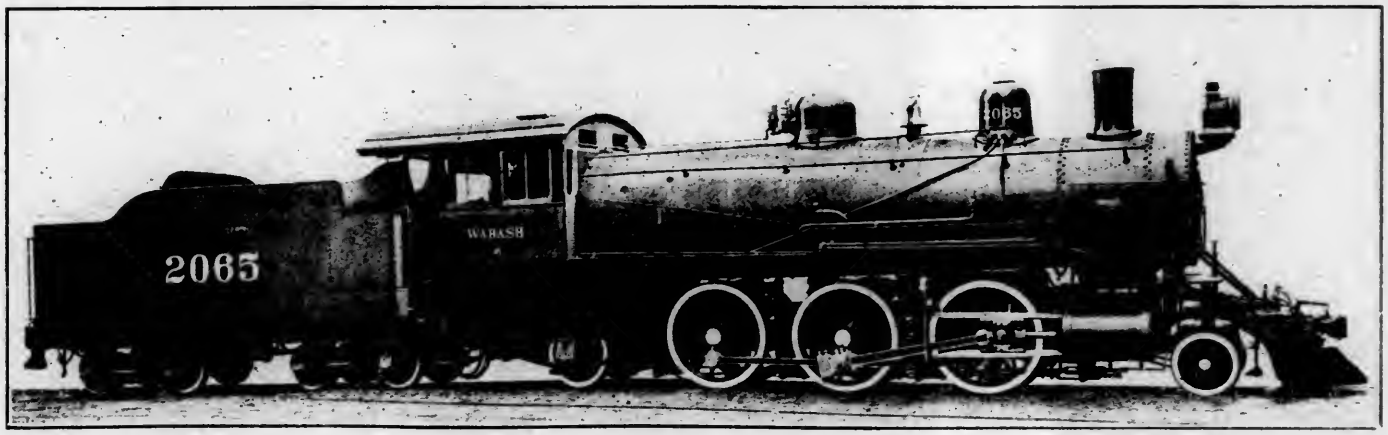
FIREBOX, PRAIRIE TYPE LOCOMOTIVE—WABASH RAILROAD.

SIMPLE PRAIRIE TYPE LOCOMOTIVES.

WABASH RAILROAD.

The American Locomotive Company is delivering an order of 60 Prairie type locomotives to the Wabash Railroad, of which 30 are fitted with 70-in. drivers, and intended for high-speed freight service, and 30 with 64-in. drivers for low speed freight service. In all other respects, except the diameter of the front truck wheels, the two classes are alike. The high speed engines have a tractive effort of 32,900 lbs., and the low speed, 36,000 lbs.

This design is very similar to, and in many respects identical with locomotives of the same type in service on the Chicago, Burlington & Quincy Railway, which were illustrated in this journal in August, 1906, page 300. The Burlington engines, however, by virtue of higher steam pressure and 1-in. smaller drivers give a higher tractive effort and are also somewhat heavier both in total weight and weight on drivers.



PRAIRIE TYPE FREIGHT LOCOMOTIVE—WABASH RAILROAD.

The boiler is of the extended wagon top type, 70 in. outside diameter at the front flue sheet and 79½ in. at the connection to the fire-box. The front flue sheet is secured in a ring of 1-in. plate to the interior of which is also fastened the front barrel sheet. The ⅝-in. smoke box sheet is riveted to the outside of this ring. The flue sheet is set 31 in. from the center line of the stack and 71½ in. from the forward end of the smoke-box. The flues, of which there are 301 2¼-in., are 19 ft. long and give a heating surface of 3,368.5 sq. ft. The fire-box, as will be seen in the illustration, is of the radial stay type with one T-iron sling stay support at the front end. Flexible staybolts are used in the breakage zones along the top and corners of the side sheets and in the throat sheet. The back head is vertical to the top of the fire door, from which point it slopes inward quite sharply. The water leg is of the same width, 4 in., from the mud ring up to the bend in the head, from which point it spreads to 9 in. at the connection to the crown sheet. The water space in the throat is 4½ in. in width at all points. The single fire door measures 14 x 28 in. Two non-lifting injectors, feeding to check valves in the usual location, are used.

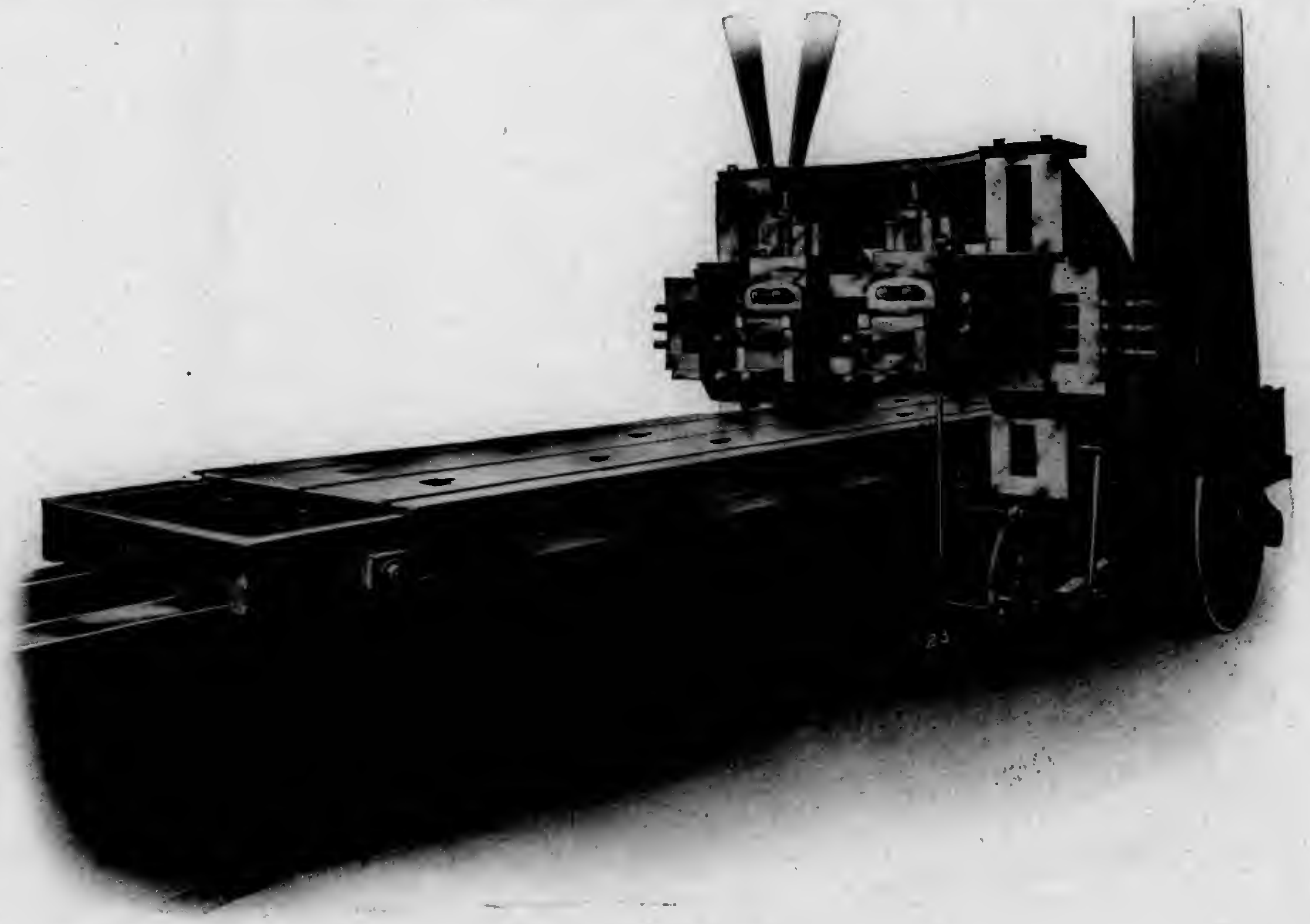
The boiler ratios are liberal, there being 65½ sq. ft. of heating surface to one square foot of grate area and 288 square feet to one cubic foot of cylinder volume. There is one square foot of heating surface to 42½ lbs. weight on drivers.

The 22 x 28-in. cylinders are served by 12-in. piston valves placed inside of the cylinders on a line with the frames. The Stephenson type of valve gear is employed, the eccentrics being on the second or main axle and the motion is transferred from the link through a transmission bar over the front axle. This bar is supported by a double hanger at its rear end and connects at the forward end to a rocker arm supported from a bearing secured below the bottom frame rail. The valve stem connection is made through a link pivoted to the rocker arm above the transmission bar connection.

The same design of trailer truck frame that has been used on the Burlington for many years is found on these engines. This consists of a heavy cast steel cross bar forming a connection between the main frames, set at 43-in. centers, and the trailer truck frames set at 80-in. centers. The trailing wheels have outside journals, the equalizer resting on top of the journal box, as shown in the illustration.

The general dimensions, weights and ratios are given in the following table:

GENERAL DATA.	
Gauge	4 ft. 8½ in.
Service	Freight
Fuel	Bit. Coal
Tractive effort	32,900 lbs.
Weight in working order	203,100 lbs.
Weight on drivers	143,100 lbs.
Weight on leading truck	26,000 lbs.
Weight on trailing truck	34,000 lbs.
Weight of engine and tender in working order	358,417 lbs.
Wheel base, driving	13 ft. 4½ in.
Wheel base, total	30 ft. 8½ in.
Wheel base, engine and tender	63 ft. 4¼ in.
RATIOS.	
Weight on drivers ÷ tractive effort	4.35
Total weight ÷ tractive effort	6.18
Tractive effort x diam. drivers ÷ heating surface	647.00
Total heating surface ÷ grate area	65.50
Firebox heating surface ÷ total heating surface, per cent	5.38
Weight on drivers ÷ total heating surface	42.50
Total weight ÷ total heating surface	57.00
Volume both cylinders, cu. ft	12.30
Total heating surface ÷ vol. cylinders	288.00
Grate area ÷ vol. cylinders	4.42
CYLINDERS.	
Kind	Simple
Diameter and stroke	22 x 28 in.
VALVES.	
Kind	Piston
Greatest travel	6⅛ in
Outside lap	1⅛ in.
Inside lap	⅛ in.
Lead in full gear	1/32 in
WHEELS.	
Driving, diameter over tires	70 in.
Driving, thickness of tires	4 in.
Driving journals, diameter and length	9½ x 12 in.
Engine truck wheels, diameter	37¼ in.
Engine truck, journals	6 x 10 in.
Trailing truck wheels, diameter	42½ in.
Trailing truck, journals	8 x 12 in.
BOILER.	
Style	Ext. Wagon Top
Working pressure	200 lbs.
Outside diameter of first ring	70 in.
Firebox, length and width	108⅛ x 72¼ in.
Firebox plates, thickness	⅜ & ½ in.
Firebox, water space	F-4½, S. & B. 4 in.
Tubes, number and outside diameter	301—2¼ in.
Tubes, length	19 ft.
Heating surface, tubes	3368.5 sq. ft.
Heating surface, firebox	190.5 sq. ft.
Heating surface, total	3559 sq. ft.
Grate area	54.24 sq. ft.
Smokestack, diameter	19½ in.
Smokestack, height above rail	15 ft. ½ in.
TENDER.	
Tank	Water Bottom
Frame	Steel
Weight, empty	61,150 lbs.
Wheels, diameter	33½ in.
Journals, diameter and length	5½ x 10 in.
Water capacity	7,700 gals.
Coal capacity	15 tons



CHANDLER CLUTCH PLANER.

CHANDLER CLUTCH PLANER.

With the introduction of high-speed steels, the individual motor drive and the resulting improvements in shop practice, the limitations of the ordinary type of planer, and especially of the larger sizes, have become very evident. Not only were the machines in use four or five years ago not of sufficiently strong and rigid construction, but it seemed to be impossible to speed them up to take full advantage of the new conditions. The various builders approached the problem from different view-points, and each in his own way has tried to solve it. The result has been a marked improvement in planer design and a number of beliefs which were current a few years ago, as to its operation and construction, have proved erroneous.

The two most obvious limitations of the belt-shifting planer are the widths of belts that can be economically shifted and the speed at which pulleys and journals can be safely run. In 1904 the Chandler Planer Co., of Ayer, Mass., built a planer which attracted widespread attention because of the remarkable work which it did. It included several radical improvements in design and was described on page 397 of our October, 1904, issue. The most important features were the use of case-hardened shafts and a second or accelerating return belt. The cutting speed was arranged to suit the material which was to be machined and at the end of the cutting stroke the platen was reversed by a belt running at a speed to secure the best reversal. As soon as the platen had been reversed and started on its return stroke, the reversing belt was thrown off and succeeded by another belt of much higher speed. At the end of the return stroke the action of the belts was reversed, the fast belt going off first and being followed by the slower or reversing belt, which retarded the mechanism just preceding the reversal to the cutting stroke.

With the higher cutting speeds and the increased weight of

parts and of the platen load on the larger size planers, and with several tools cutting at the same time, there was a call for an increased belt ratio and the belt problem again became serious.

To relieve this difficulty it soon became evident that the shifting belts must be replaced by clutches or some similar device. The requirements of the clutch in planer operation are very different and much more severe than that for clutches in other kinds of service, and it was found necessary to design a clutch along new lines. The Chandler Planer Company has designed such a clutch and adapted it to their planer and for a considerable period have been submitting it to severe and protracted tests.

The planer is 42 in. x 20 in. x 20 ft. and weighs about 30 tons. In order to test the clutches on the severest class of work, the planer is of the frog and switch type. Its cutting speed is 20 ft., with a return of 4 to 1. The cutting belt is 10 in. double and runs at a speed of 1,860 ft. per minute, with ratio of 93 ft. of belt to 1 ft. of platen. The reversing belt is 5 in. wide and runs at a speed of 3,900 ft. per minute. The dimensions of most of the tools used in the tests were 2½ in. x 3 in., and were of various makes of high-speed steels.

The planer removes the side of the head, up to the web, on a pair of extra hard 70 lb. relay switch points, cutting back 9 ft. in less than 6 minutes. It is expected that this time can be reduced at least 30 per cent. At a cutting speed of 20 ft. it removed from a 40-point carbon steel forging, a chip ¾ in. deep, with ¾ in. feed. It runs for hours on a 14 in. stroke, without giving the slightest indication of injurious heating or wearing. It is said to reverse as smoothly as the best belt-shifting planer.

The clutches, which are two in number, of the multiple disc type, are located inside the bed of the planer on the second shaft, and are set by mechanism operated by the planer. All the dog or the operator can do is to trip the mechanism. The advantages claimed for the clutches are that they provide a maximum bearing surface with a fixed minimum slip, avoidance of metal contact, a positive rather than a friction locking, elimination of shock, reduction of momentum, locking proportionate to the load, and impossibility of slipping when once set.

These results are secured in the following manner:

The heating problem, which, perhaps, of all others, is the most to be feared, is overcome by sufficiently large bearing surfaces made up of multiple discs, alternate discs being keyed to the shaft and shell of the clutch, and all moving laterally. When the clutch is closed the discs are pressed together.

The amount of slip before locking, is accurately determined by a timing mechanism between a primary clutch and the main clutch.

The two clutches operate on the principle of differentials. The amount of locking of the main clutch is, therefore, determined by the difference in movement of the two clutches. It is obvious that any slip of either clutch increases the grip of the main clutch, and insures a locking in proportion to the load. In a sense, the main clutches are positive rather than friction.

The shell of the main clutch is a case within which the discs run in a bath of oil. The oil not only lubricates and reduces the chance of heating, but serves as a cushion which gives the clutches a soft, smooth engagement. Examination of the discs, after severe and protracted tests, indicate that a film of oil is always interposed between their faces. It is obvious that so long as the discs do not come into metal contact there can be no wearing and no heating.

The clutches are two in number, one engages with the cutting belt shaft and one with the reversing belt shaft. Consequently, one clutch is idle while the other is in operation. This gives the idle clutch a chance to rest and become thoroughly lubricated before engaging.

The clutches are self-contained. When engaged, both the primary and main clutch revolve as one clutch.

As momentum is the product of weight multiplied by velocity, every material reduction of either greatly reduces the difficulty of reversing. In the Chandler clutch planer the clutches are on the second shaft, and the only parts of the clutch that reverse are the discs that are keyed on the shaft. The clutch case and all the other operating mechanism moves constantly in one direction.

Supplementing the primary and main clutches is a mechanically operated device which insures a proper and positive engagement of the primary clutch and leaves nothing to the mischance of dogging, and provides a proper margin of safety to meet all the conditions of varying platen load.

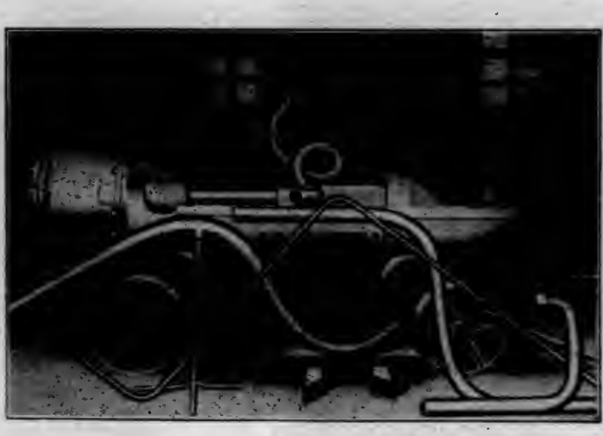
The clutches are located inside the bed of the planer. They, therefore, add nothing to its size, and do not, in any way, change its general appearance.

To run the planer light at a cutting speed of 20 ft. with return speed of 4 to 1, requires 6 to 7 h.p. on either stroke. The reverse requires about 20 h.p. On severe cutting loads the clutches have demonstrated ability to hold without slipping under a load of over 50 h.p.

Some surprising cutting results were obtained with high-speed steels on this planer. Most frog and switch builders claim that they are able to reach the limit of their tool steels, with planers of far less power than is utilized by the Chandler clutch planer. The management of Chandler Planer Company claim that its planer secures a greatly increased cutting efficiency because of its steadiness. They contend that the molecular structure of high-speed steel is upset by shock, especially at a high temperature; that this is demonstrated by the fact that after a tool is forged it has no cutting capacity until the molecules are permitted to readjust by the process of annealing. If the planer vibrates and chatters while the tool is in the chip, there takes place in the tool, especially in its cutting edge, a disturbance practically the same as that which results from forging.

PNEUMATIC PIPE BENDING MACHINE.

The portable pneumatic pipe bending machine, which is quite clearly shown in the accompanying illustration, is being placed upon the market by H. B. Underwood & Co., Philadelphia, Pa. One of these machines has been in practical use in a large railroad repair shop for several months and has done all the pipe

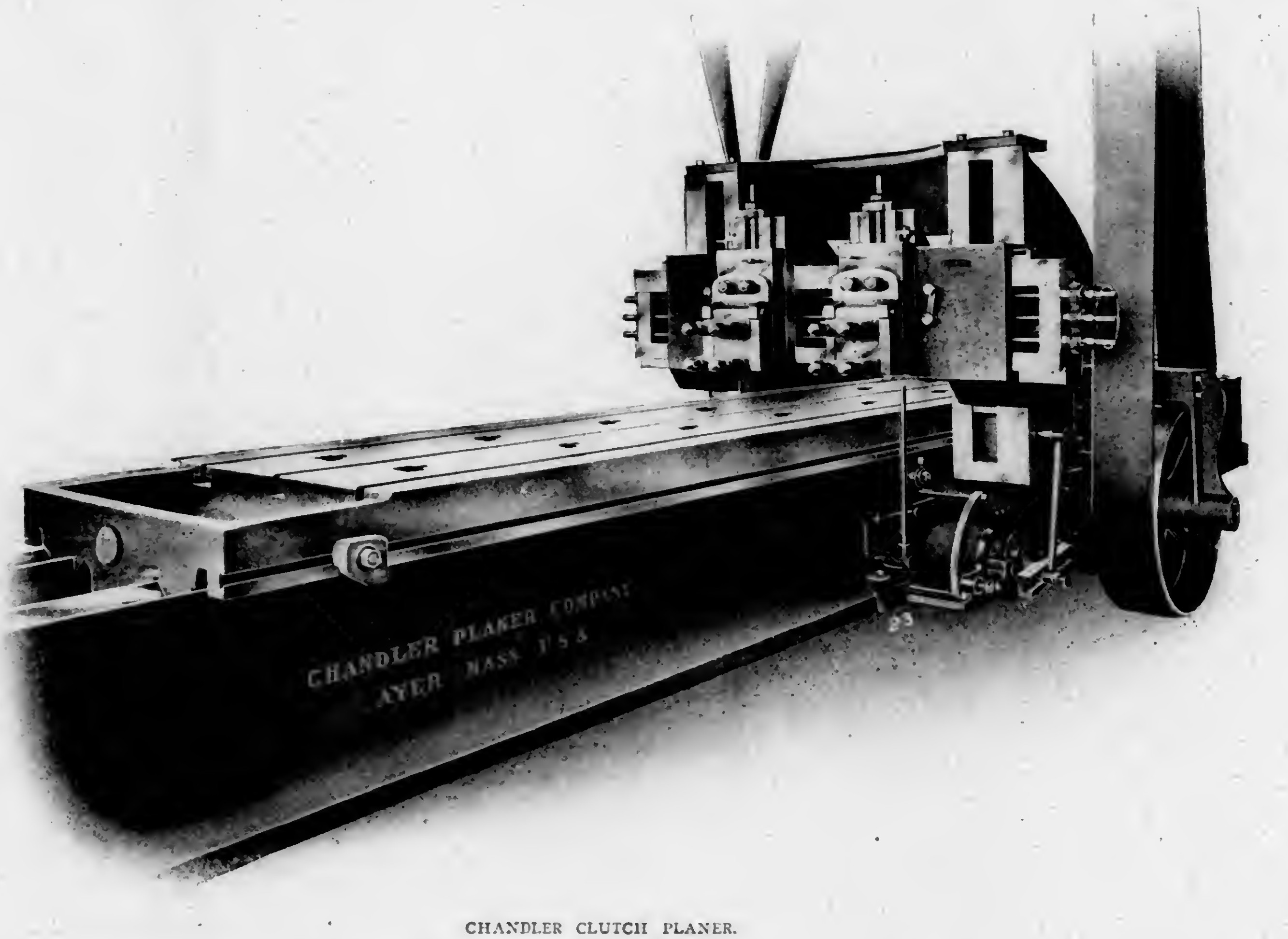


PORTABLE PNEUMATIC PIPE BENDING MACHINE.

bending required in connection with the locomotive equipment, air brakes and regular work. It does not flatten or injure the pipe in any way and will make a right angle bend in a 2-in. pipe in two minutes. Dies are furnished of standard radius, for locomotive work, for from ½ to 2-in. pipe, and special dies of any required radius or shape may be furnished to order.

Definition of a Mechanical Engineer.—"The mechanical engineer is one who by science and by art so adapts and applies the physical properties of matter and so controls the forces which act through them as to serve the use and convenience of man and to advance his economic and material welfare. He does this mainly by storing and liberating motor energy through machines and apparatus which he designs and installs and operates for the purpose of fostering and developing tne processes of industrial production which use and require such power upon a large scale."—*Pres. Hutton before the Amer. Soc. Mech. Eng.*

GENERAL DATA.	
Gauge	4 ft. 8½ in.
Service	Freight
Fuel	Bit. Coal
Tractive effort	32,900 lbs.
Weight in working order	203,100 lbs.
Weight on drivers	143,100 lbs.
Weight on leading truck	26,000 lbs.
Weight on trailing truck	34,000 lbs.
Weight of engine and tender in working order	358,417 lbs.
Wheel base, driving	13 ft. 1½ in.
Wheel base, total	30 ft. 8½ in.
Wheel base, engine and tender	63 ft. 1¼ in.
RATIOS.	
Weight on drivers ÷ tractive effort	4.35
Total weight ÷ tractive effort	6.18
Tractive effort × diam. drivers ÷ heating surface	647.00
Total heating surface ÷ grate area	65.50
Firebox heating surface ÷ total heating surface, per cent	5.38
Weight on drivers ÷ total heating surface	42.50
Total weight ÷ total heating surface	57.00
Volume both cylinders, cu. ft.	12.30
Total heating surface ÷ vol. cylinders	288.00
Grate area ÷ vol. cylinders	4.42
CYLINDERS.	
Kind	Simple
Diameter and stroke	22 x 28 in.
VALVES.	
Kind	Piston
Greatest travel	6⅛ in.
Outside lap	1⅛ in.
Inside lap	[illegible] in.
Lead in full gear	1/32 in.
WHEELS.	
Driving, diameter over tires	70 in.
Driving, thickness of tires	4 in.
Driving journals, diameter and length	9½ x 12 in.
Engine truck wheels, diameter	37¼ in.
Engine truck, journals	6 x 10 in.
Trailing truck wheels, diameter	42½ in.
Trailing truck, journals	8 x 12 in.
BOILER.	
Style	Ext. Wagon Top
Working pressure	200 lbs.
Outside diameter of first ring	70 in.
Firebox, length and width	108⅛ x 72¼ in.
Firebox plates, thickness	⅜ & ½ in.
Firebox, water space	F-4½, S. & B. 4 in.
Tubes, number and outside diameter	301—2¼ in.
Tubes, length	19 ft.
Heating surface, tubes	3368.5 sq. ft.
Heating surface, firebox	190.5 sq. ft.
Heating surface, total	3559 sq. ft.
Grate area	54.24 sq. ft.
Smokestack, diameter	19½ in.
Smokestack, height above rail	15 ft. ½ in.
TENDER.	
Tank	Water Bottom
Frame	Steel
Weight, empty	61,150 lbs.
Wheels, diameter	33¼ in.
Journals, diameter and length	5½ x 10 in.
Water capacity	7,700 gals.
Coal capacity	15 tons



CHANDLER CLUTCH PLANER.

CHANDLER CLUTCH PLANER.

With the introduction of high-speed steels, the individual motor drive and the resulting improvements in shop practice, the limitations of the ordinary type of planer, and especially of the larger sizes, have become very evident. Not only were the machines in use four or five years ago not of sufficiently strong and rigid construction, but it seemed to be impossible to speed them up to take full advantage of the new conditions. The various builders approached the problem from different view-points, and each in his own way has tried to solve it. The result has been a marked improvement in planer design and a number of beliefs which were current a few years ago, as to its operation and construction, have proved erroneous.

The two most obvious limitations of the belt-shifting planer are the widths of belts that can be economically shifted and the speed at which pulleys and journals can be safely run. In 1904 the Chandler Planer Co., of Ayer, Mass., built a planer which attracted widespread attention because of the remarkable work which it did. It included several radical improvements in design and was described on page 397 of our October, 1904, issue. The most important features were the use of case-hardened shafts and a second or accelerating return belt. The cutting speed was arranged to suit the material which was to be machined and at the end of the cutting stroke the platen was reversed by a belt running at a speed to secure the best reversal. As soon as the platen had been reversed and started on its return stroke, the reversing belt was thrown off and succeeded by another belt of much higher speed. At the end of the return stroke the action of the belts was reversed, the fast belt going off first and being followed by the slower or reversing belt, which retarded the mechanism just preceding the reversal to the cutting stroke.

With the higher cutting speeds and the increased weight of

parts and of the platen load on the larger size planers, and with several tools cutting at the same time, there was a call for an increased belt ratio and the belt problem again became serious.

To relieve this difficulty it soon became evident that the shifting belts must be replaced by clutches or some similar device. The requirements of the clutch in planer operation are very different and much more severe than that for clutches in other kinds of service, and it was found necessary to design a clutch along new lines. The Chandler Planer Company has designed such a clutch and adapted it to their planer and for a considerable period have been submitting it to severe and protracted tests.

The planer is 42 in. x 20 in. x 20 ft. and weighs about 30 tons. In order to test the clutches on the severest class of work, the planer is of the frog and switch type. Its cutting speed is 20 ft., with a return of 4 to 1. The cutting belt is 10 in. double and runs at a speed of 1,800 ft. per minute, with ratio of 93 ft. of belt to 1 ft. of platen. The reversing belt is 5 in. wide and runs at a speed of 3,900 ft. per minute. The dimensions of most of the tools used in the tests were 2½ in. x 3 in., and were of various makes of high-speed steels.

The planer removes the side of the head, up to the web, on a pair of extra hard 70 lb. relay switch points, cutting back 9 ft. in less than 6 minutes. It is expected that this time can be reduced at least 30 per cent. At a cutting speed of 20 ft. it removed from a 40-point carbon steel forging, a chip ¾ in. deep, with ¾ in. feed. It runs for hours on a 14 in. stroke, without giving the slightest indication of injurious heating or wearing. It is said to reverse as smoothly as the best belt-shifting planer.

The clutches, which are two in number, of the multiple disc type, are located inside the bed of the planer on the second shaft, and are set by mechanism operated by the planer. All the dog or the operator can do is to trip the mechanism. The advantages claimed for the clutches are that they provide a maximum bearing surface with a fixed minimum slip, avoidance of metal contact, a positive rather than a friction locking, elimination of shock, reduction of momentum, locking proportionate to the load, and impossibility of slipping when once set.

These results are secured in the following manner:

The heating problem, which, perhaps, of all others, is the most to be feared, is overcome by sufficiently large bearing surfaces made up of multiple discs, alternate discs being keyed to the shaft and shell of the clutch, and all moving laterally. When the clutch is closed the discs are pressed together.

The amount of slip before locking, is accurately determined by a timing mechanism between a primary clutch and the main clutch.

The two clutches operate on the principle of differentials. The amount of locking of the main clutch is, therefore, determined by the difference in movement of the two clutches. It is obvious that any slip of either clutch increases the grip of the main clutch, and insures a locking in proportion to the load. In a sense, the main clutches are positive rather than friction.

The shell of the main clutch is a case within which the discs run in a bath of oil. The oil not only lubricates and reduces the chance of heating, but serves as a cushion which gives the clutches a soft, smooth engagement. Examination of the discs, after severe and protracted tests, indicate that a film of oil is always interposed between their faces. It is obvious that so long as the discs do not come into metal contact there can be no wearing and no heating.

The clutches are two in number, one engages with the cutting belt shaft and one with the reversing belt shaft. Consequently, one clutch is idle while the other is in operation. This gives the idle clutch a chance to rest and become thoroughly lubricated before engaging.

The clutches are self-contained. When engaged, both the primary and main clutch revolve as one clutch.

As momentum is the product of weight multiplied by velocity, every material reduction of either greatly reduces the difficulty of reversing. In the Chandler clutch planer the clutches are on the second shaft, and the only parts of the clutch that reverse are the discs that are keyed on the shaft. The clutch case and all the other operating mechanism moves constantly in one direction.

Supplementing the primary and main clutches is a mechanically operated device which insures a proper and positive engagement of the primary clutch and leaves nothing to the mischance of dogging, and provides a proper margin of safety to meet all the conditions of varying platen load.

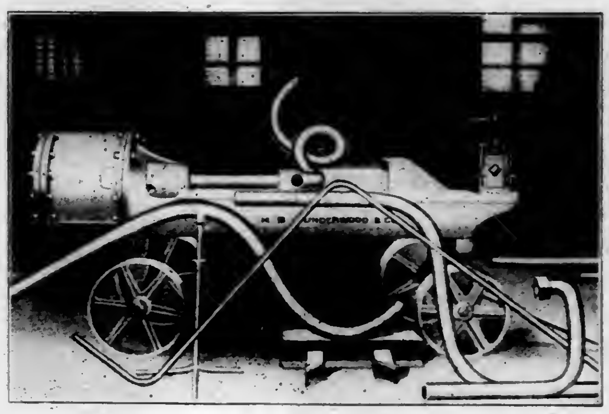
The clutches are located inside the bed of the planer. They, therefore, add nothing to its size, and do not, in any way, change its general appearance.

To run the planer light at a cutting speed of 20 ft. with return speed of 4 to 1, requires 6 to 7 h.p. on either stroke. The reverse requires about 20 h.p. On severe cutting loads the clutches have demonstrated ability to hold without slipping under a load of over 50 h.p.

Some surprising cutting results were obtained with high-speed steels on this planer. Most frog and switch builders claim that they are able to reach the limit of their tool steels, with planers of far less power than is utilized by the Chandler clutch planer. The management of Chandler Planer Company claim that its planer secures a greatly increased cutting efficiency because of its steadiness. They contend that the molecular structure of high-speed steel is upset by shock, especially at a high temperature; that this is demonstrated by the fact that after a tool is forged it has no cutting capacity until the molecules are permitted to readjust by the process of annealing. If the planer vibrates and chatters while the tool is in the chip, there takes place in the tool, especially in its cutting edge, a disturbance practically the same as that which results from forging.

PNEUMATIC PIPE BENDING MACHINE.

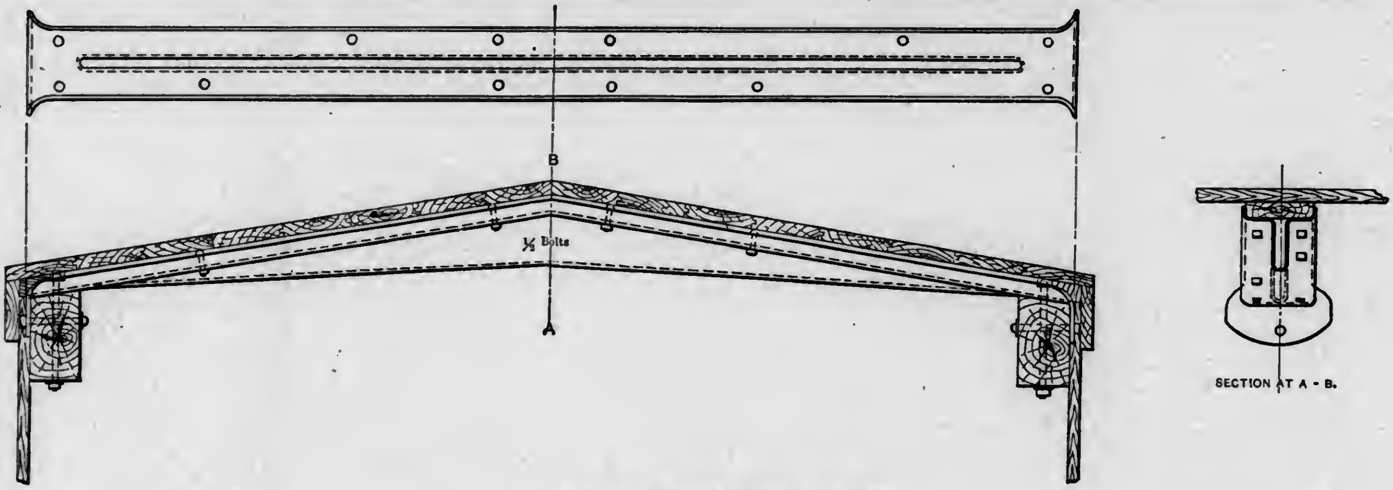
The portable pneumatic pipe bending machine, which is quite clearly shown in the accompanying illustration, is being placed upon the market by H. B. Underwood & Co., Philadelphia, Pa. One of these machines has been in practical use in a large railroad repair shop for several months and has done all the pipe



PORTABLE PNEUMATIC PIPE BENDING MACHINE.

bending required in connection with the locomotive equipment, air brakes and regular work. It does not flatten or injure the pipe in any way and will make a right angle bend in a 2-in. pipe in two minutes. Dies are furnished of standard radius, for locomotive work, for from ½ to 2-in. pipe, and special dies of any required radius or shape may be furnished to order.

DEFINITION OF A MECHANICAL ENGINEER.—"The mechanical engineer is one who by science and by art so adapts and applies the physical properties of matter and so controls the forces which act through them as to serve the use and convenience of man and to advance his economic and material welfare. He does this mainly by storing and liberating motor energy through machines and apparatus which he designs and installs and operates for the purpose of fostering and developing the processes of industrial production which use and require such power upon a large scale."—*Pres. Hutton before the Amer. Soc. Mech. Eng.*



CLEVELAND PRESSED STEEL CARLINE.

PRESSED STEEL CARLINES.

One of the most important developments in box car design and construction has been the introduction of pressed steel carlines. That this type of carline is made in one piece and that it can be used to replace the wooden carline without any change in the construction of either the car body or the roof, are important points in its favor. Compared to the wooden carline a stronger roof support may be gained with a less number of steel carlines, with less weight per car, and in most cases with greater inside clearance.

The Cleveland Car Specialty Company of Cleveland has designed a new pattern of pressed steel carline, specially adapted to the outside metal roof, in which a channel section is reinforced by a U-section pressed into the web of the channel. The channel section, with a 5-in. nailing strip bolted to it, gives a wide support for the longitudinal course of boards and the additional strength due to the U-section makes a stronger carline with less weight than any possible combination of wood and iron, or any commercial shape that may be used.

The importance of adding strength to freight cars without increasing their weight is generally recognized. Tests and experiments show that in practically all cases a pressed steel shape will give better results in this respect than commercial shapes, as additional strength may readily be provided where it is required. This is specially true of compound shapes, which must be built up and bolted or riveted together.

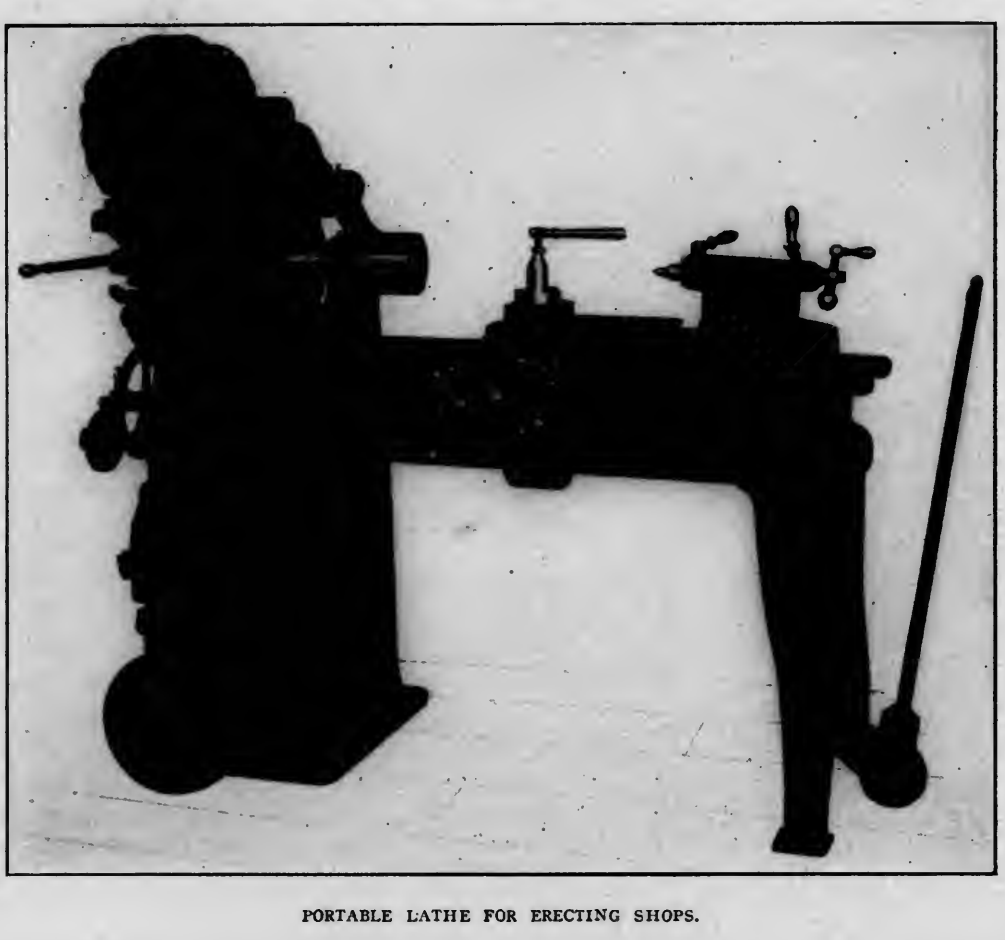
The Cleveland pressed steel carlines are made in a number of different patterns suitable for different types of construction. The new type, which has been described, is said to be an ideal one for the outside metal roof, combining, as it does, the superior design with lightness, and extending over the side plates.

International Master Boiler Makers' Association.—The International Railway and the Master Steam Boiler Makers' Associations consolidated last spring to form this Association. The next convention will be held in Detroit, May 26, 27 and 28. Mr. George Wagstaff, supervisor of boilers of the New York Central Lines, is its president.

PORTABLE LATHE FOR ERECTING SHOPS.

A portable bolt turning machine is being used to considerable advantage in the erecting shop of the Canadian Pacific Railway at Angus, Montreal. The base is provided with three wheels which are fitted with roller bearings. When the handle is in an upright position the two forward legs of the bed rest on the floor and the machine is level. When the handle is pulled forward these legs are raised from the floor, the weight resting on the small front wheel, and the machine may be easily moved from place to place. Three-quarters of the weight rests upon the two large wheels at the rear.

The machine is driven by a 2 h.p. Westinghouse induction motor, 1,700 r. p. m., the starting device for which is shown at the front of the machine. The gearing is arranged for either 200 or 400 revolutions per minute of the lathe spindle; change from one speed to the other is made by moving the lever which controls the friction clutches. The nose of the spindle is fitted with a chuck, suitable to the size of bolt which is being turned and into which the bolt head fits. This merely drives the work,



PORTABLE LATHE FOR ERECTING SHOPS.

which otherwise is held between centers in the ordinary manner. Different feeds are provided for by means of change gears. In other respects the machine is a standard engine lathe without a screw feed. It is manufactured by the Williams & Wilson Company of Montreal and has a swing of 16½ in. and a length between centers of 26 in.

PORTABLE WORK-BENCHES FOR ROUND HOUSES AND ERECTING SHOPS.

The portable work benches, shown in the accompanying illustrations, were especially designed for use in roundhouses and erecting shops by the Western Tool & Manufacturing Company

PORTABLE TOOL STAND.

PORTABLE VISE STAND.

of Springfield, O. Shop managers seem to be realizing, more and more, the importance of adding facilities of this kind for the purpose of increasing the output and in the interests of time saving and economy. When the handle is in an upright position, as shown, the brakes on the rear wheels are applied and the front part of the base rests on the floor. Pulling the handle forward releases the brakes and throws the front wheel into operation, allowing the bench to be easily moved. The drawers are fitted with locks.

The vise stand is made in two sizes, as follows:

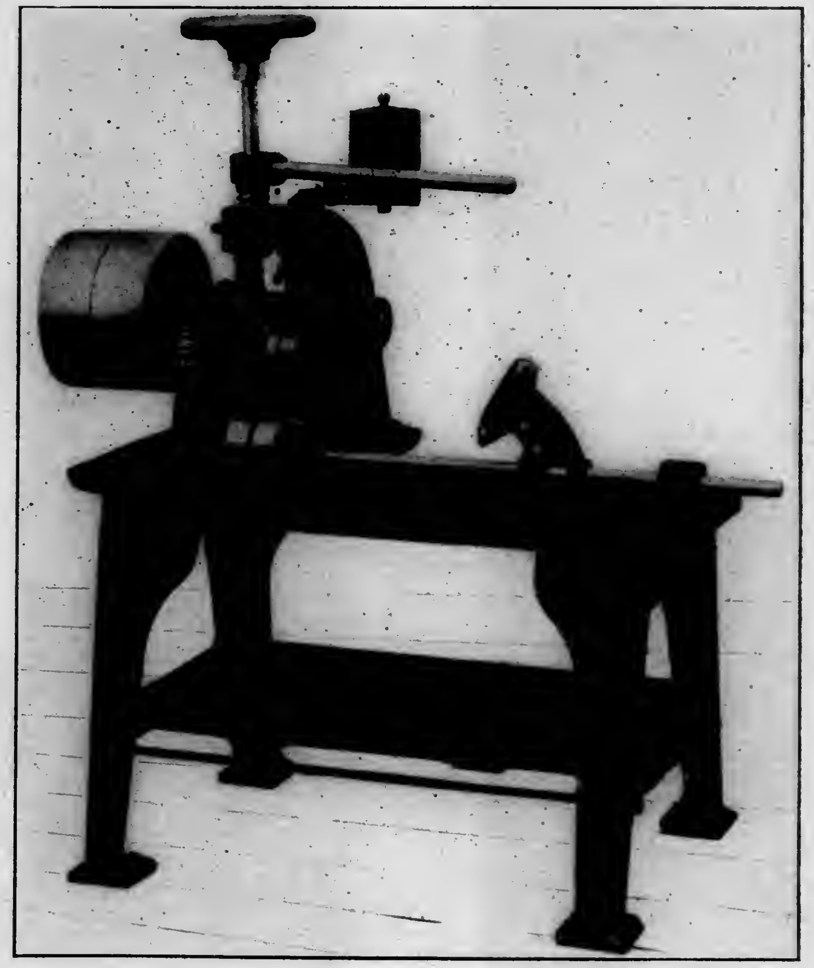
Height	44 in.	44 in.
Base	26 in.	29 in.
Table and shelf	17 x 21 in.	21 x 25 in.
Weight, crated	350 lbs.	575 lbs.

These stands may be furnished with either plain jaw vises or combination pipe jaw vises.

The tool stand is 40 in. high; the top shelf is 22 x 30 in. and the others 22 x 24 in. The distance between the shelves is 7 in. The stand weighs 300 lbs. and may be furnished either with or without the vise.

NEW PIPE AND TUBE CUTTER.

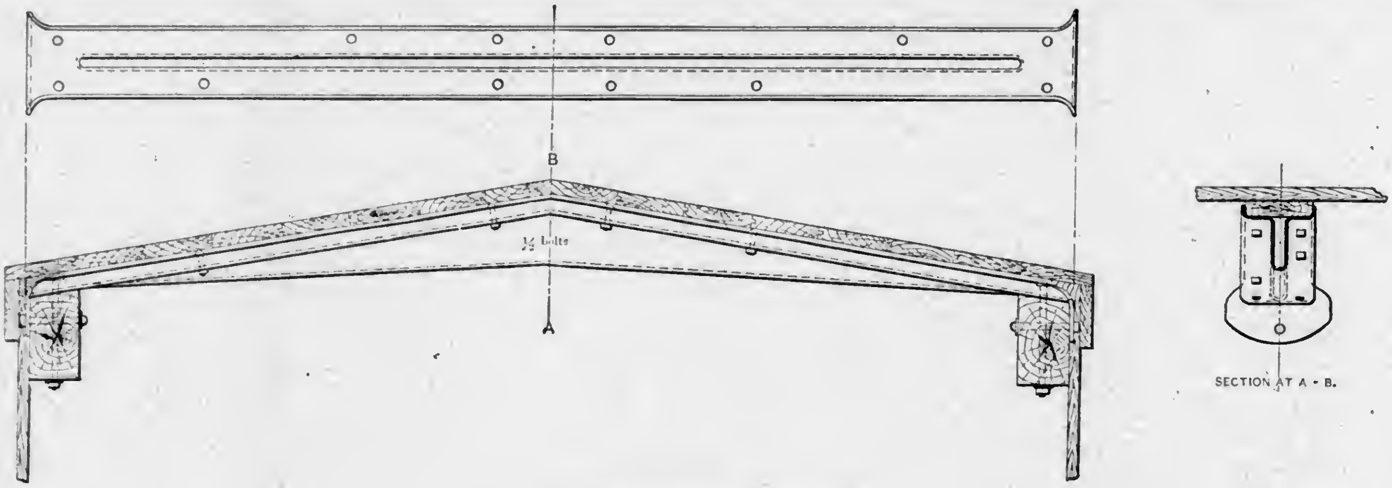
A new rolling pipe and tube cutter, designed for quick and accurate service, with a capacity of from 1 to 4 in., has just



NEW PIPE AND TUBE CUTTER.

been placed on the market by the Bignall & Keeler Mfg. Co. of Edwardsville, Ill. The cutting is accomplished by lowering the cutter and not by raising the pipe, thus allowing the pipe to bear evenly across the entire length of the roll.

The cutter shaft is carried in an arm which is pivoted at one end and is raised and lowered by means of a screw. The cutter is adjusted until it just clears the pipe and then by using the lever, which terminates in a nut having a coarse thread, the cutter can be quickly raised and lowered. The gears are cut from the solid. The machine may be furnished either with or without a table. When a table is furnished a movable stop is provided for cutting duplicate lengths.



CLEVELAND PRESSED STEEL CARLINE.

PRESSED STEEL CARLINES.

One of the most important developments in box car design and construction has been the introduction of pressed steel carlines. That this type of carline is made in one piece and that it can be used to replace the wooden carline without any change in the construction of either the car body or the roof, are important points in its favor. Compared to the wooden carline a stronger roof support may be gained with a less number of steel carlines, with less weight per car, and in most cases with greater inside clearance.

The Cleveland Car Specialty Company of Cleveland has designed a new pattern of pressed steel carline, specially adapted to the outside metal roof, in which a channel section is reinforced by a U-section pressed into the web of the channel. The channel section, with a 5-in. nailing strip bolted to it, gives a wide support for the longitudinal course of boards and the additional strength due to the U-section makes a stronger carline with less weight than any possible combination of wood and iron, or any commercial shape that may be used.

The importance of adding strength to freight cars without increasing their weight is generally recognized. Tests and experiments show that in practically all cases a pressed steel shape will give better results in this respect than commercial shapes, as additional strength may readily be provided where it is required. This is specially true of compound shapes, which must be built up and bolted or riveted together.

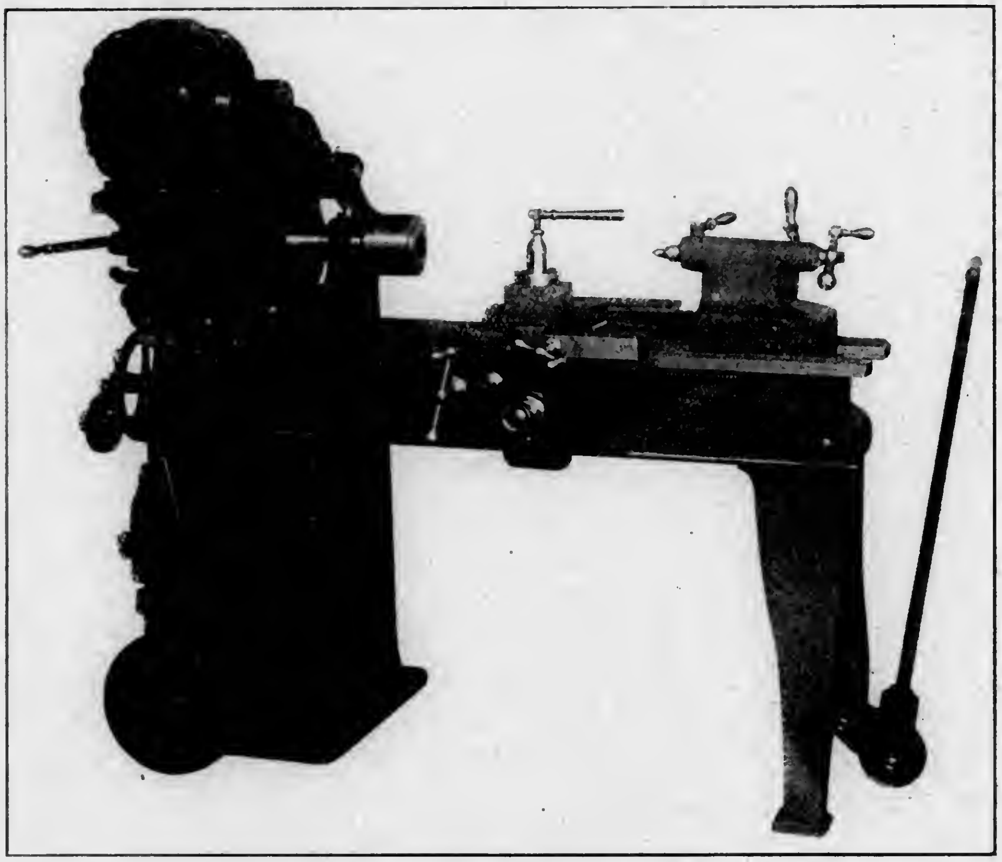
The Cleveland pressed steel carlines are made in a number of different patterns suitable for different types of construction. The new type, which has been described, is said to be an ideal one for the outside metal roof, combining, as it does, the superior design with lightness, and extending over the side plates.

International Master Boiler Makers' Association.—The International Railway and the Master Steam Boiler Makers' Associations consolidated last spring to form this Association. The next convention will be held in Detroit, May 26, 27 and 28. Mr. George Wagstaff, supervisor of boilers of the New York Central Lines, is its president.

PORTABLE LATHE FOR ERECTING SHOPS.

A portable bolt turning machine is being used to considerable advantage in the erecting shop of the Canadian Pacific Railway at Angus, Montreal. The base is provided with three wheels which are fitted with roller bearings. When the handle is in an upright position the two forward legs of the bed rest on the floor and the machine is level. When the handle is pulled forward these legs are raised from the floor, the weight resting on the small front wheel, and the machine may be easily moved from place to place. Three-quarters of the weight rests upon the two large wheels at the rear.

The machine is driven by a 2 h.p. Westinghouse induction motor, 1,700 r. p. m., the starting device for which is shown at the front of the machine. The gearing is arranged for either 200 or 400 revolutions per minute of the lathe spindle; change from one speed to the other is made by moving the lever which controls the friction clutches. The nose of the spindle is fitted with a chuck, suitable to the size of bolt which is being turned and into which the bolt head fits. This merely drives the work,



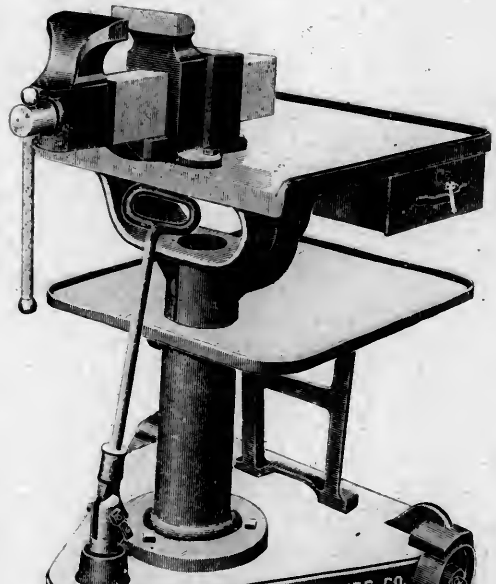
PORTABLE LATHE FOR ERECTING SHOPS.

which otherwise is held between centers in the ordinary manner. Different feeds are provided for by means of change gears. In other respects the machine is a standard engine lathe without a screw feed. It is manufactured by the Williams & Wilson Company of Montreal and has a swing of 16½ in. and a length between centers of 26 in.

PORTABLE WORK-BENCHES FOR ROUND HOUSES AND ERECTING SHOPS.

The portable work benches, shown in the accompanying illustrations, were especially designed for use in roundhouses and erecting shops by the Western Tool & Manufacturing Company

PORTABLE TOOL STAND.



PORTABLE VISE STAND.

of Springfield, O. Shop managers seem to be realizing, more and more, the importance of adding facilities of this kind for the purpose of increasing the output and in the interests of time saving and economy. When the handle is in an upright position, as shown, the brakes on the rear wheels are applied and the front part of the base rests on the floor. Pulling the handle forward releases the brakes and throws the front wheel into operation, allowing the bench to be easily moved. The drawers are fitted with locks.

The vise stand is made in two sizes, as follows:

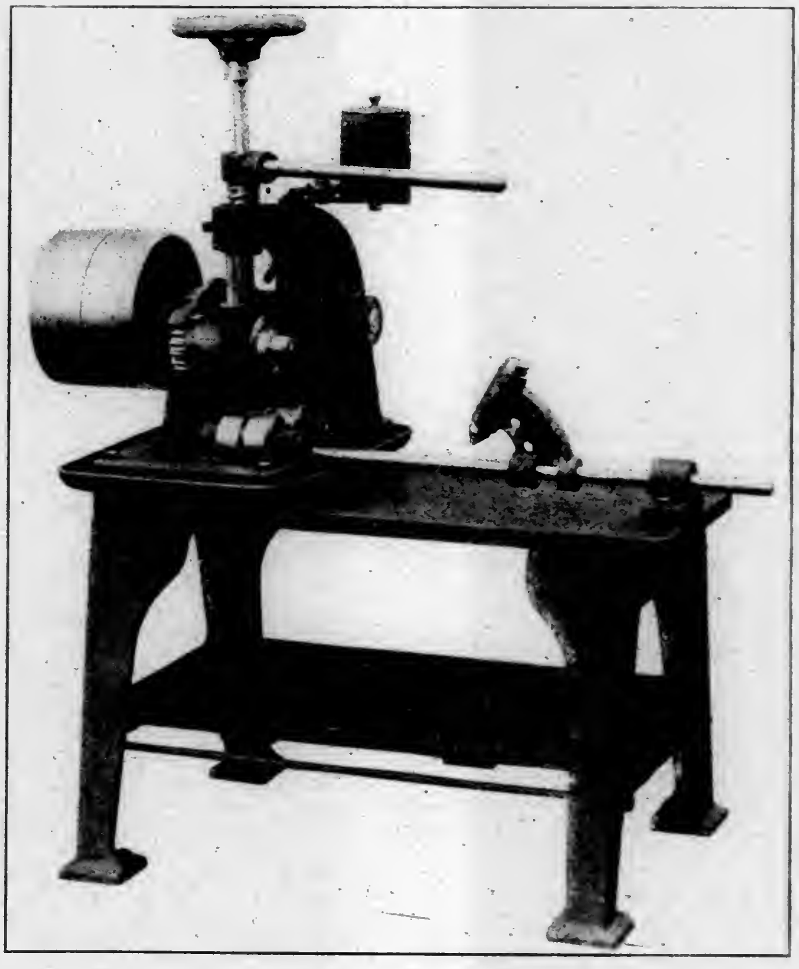
Height	44 in.	44 in.
Base	26 in.	29 in.
Table and shelf	17 x 21 in.	21 x 25 in.
Weight, crated	350 lbs.	575 lbs.

These stands may be furnished with either plain jaw vises or combination pipe jaw vises.

The tool stand is 40 in. high; the top shelf is 22 x 30 in. and the others 22 x 24 in. The distance between the shelves is 7 in. The stand weighs 300 lbs. and may be furnished either with or without the vise.

NEW PIPE AND TUBE CUTTER.

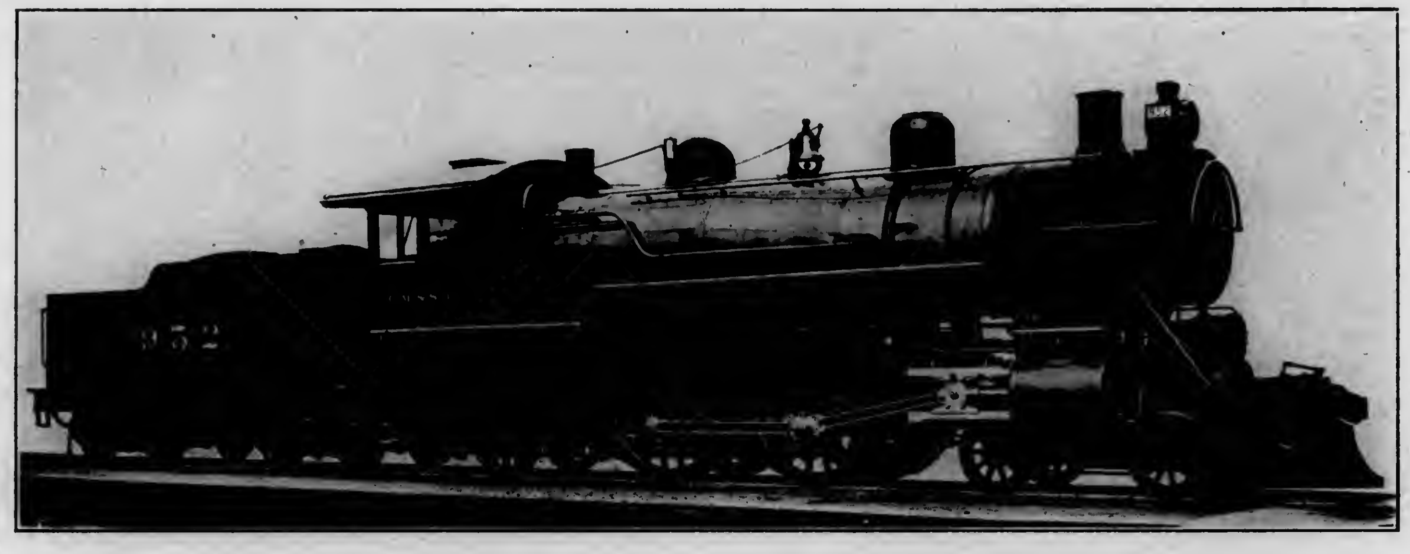
A new rolling pipe and tube cutter, designed for quick and accurate service, with a capacity of from 1 to 4 in., has just

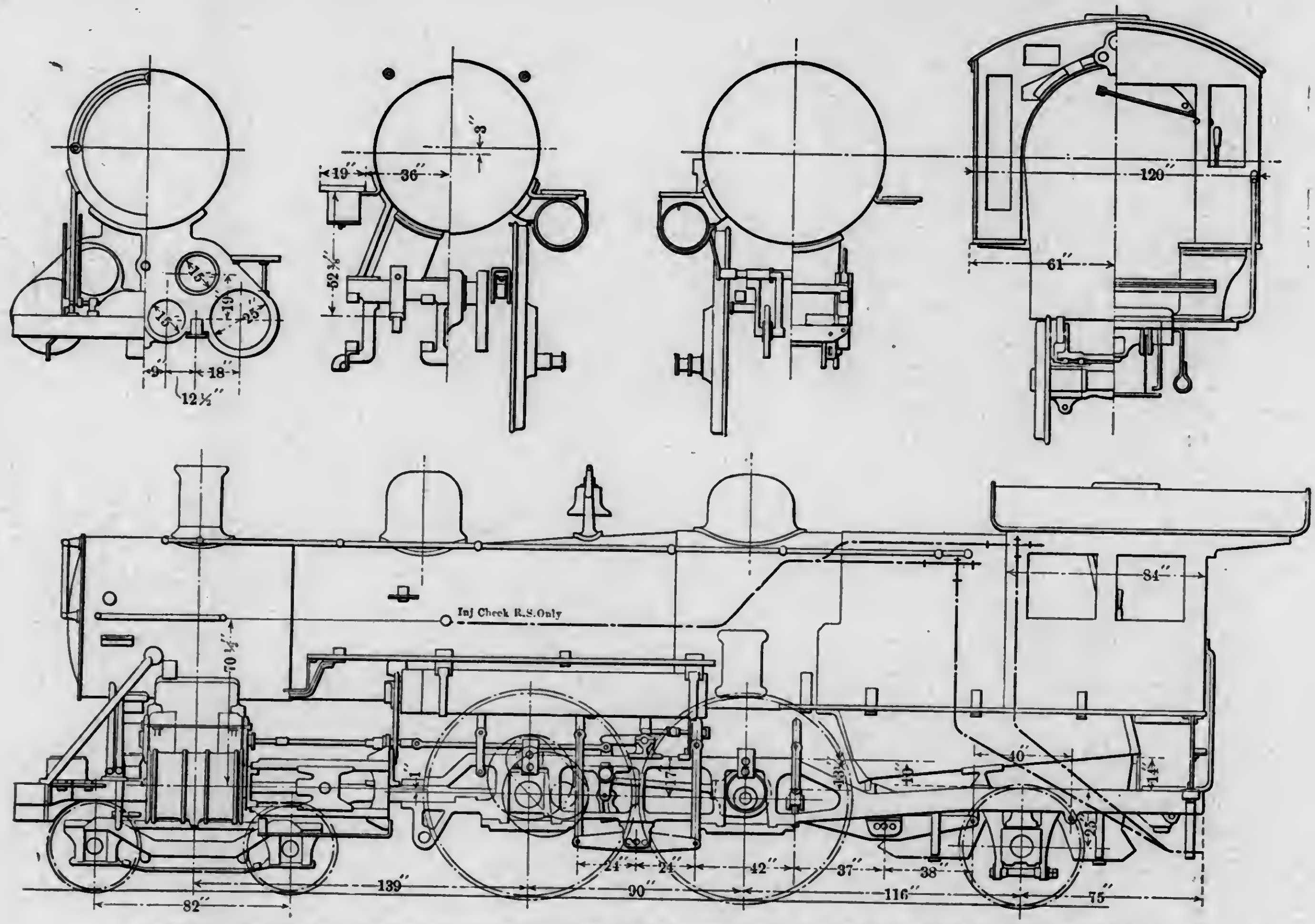


NEW PIPE AND TUBE CUTTER.

been placed on the market by the Bignall & Keeler Mfg. Co. of Edwardsville, Ill. The cutting is accomplished by lowering the cutter and not by raising the pipe, thus allowing the pipe to bear evenly across the entire length of the roll.

The cutter shaft is carried in an arm which is pivoted at one end and is raised and lowered by means of a screw. The cutter is adjusted until it just clears the pipe and then by using the lever, which terminates in a nut having a coarse thread, the cutter can be quickly raised and lowered. The gears are cut from the solid. The machine may be furnished either with or without a table. When a table is furnished a movable stop is provided for cutting duplicate lengths.





BALDWIN BALANCED COMPOUND ATLANTIC TYPE LOCOMOTIVE, CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.

BALANCED COMPOUND PASSENGER LOCOMOTIVES.

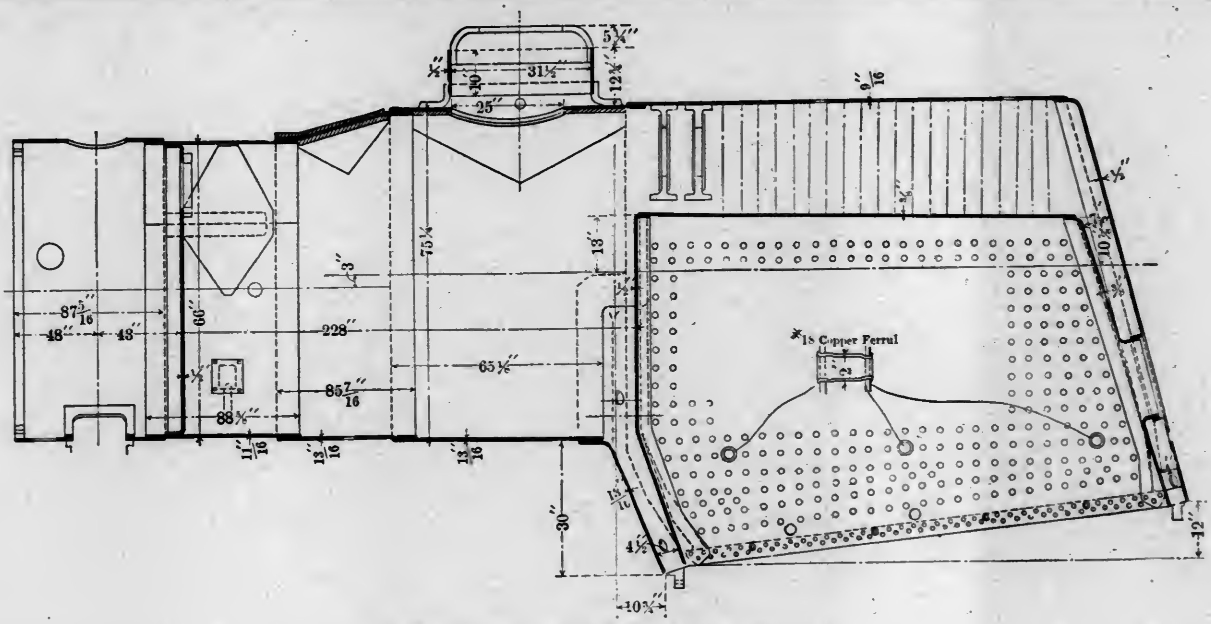
CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.

The Baldwin Locomotive Works has recently delivered two balanced compound Atlantic type locomotives to the Chicago, Milwaukee & St. Paul Railway, which are to be used in fast passenger service and have a tractive effort of 22,200 lbs. working compound.

These locomotives, as far as the arrangement of cylinders and running gear is concerned, do not differ in any essential features from most of the Baldwin compound locomotives of this type. The cylinders are set side by side in a horizontal line and all drive on the front pair of wheels; the cranked axle being of the built up type with a cast steel central web. The Stephenson type of valve gear is used, the eccentrics necessarily being on the rear driving axle. The link is located just back of the front axle and the rocker arm is so placed as to connect directly to the link block. The top of the rocker arm extends over the frame so as to connect directly to the valve rod, which passes along the top of the frame from this point to the 15-in. piston valve. This rod has a bearing in the guide yoke and is provided with a knuckle joint just back of this bearing.

The frames are of cast steel 4½ in. wide with single front frames of wrought iron. The DeVoy type of trailer truck* is used, which employs a trailer truck frame of the slab form 2¾ in. wide by 10 in. deep. The trailer truck boxes form part of a steel casting extending across the engine and are guided by

* See AMERICAN ENGINEER, April, 1905, pp. 135.



LONGITUDINAL SECTION THROUGH BOILER.

pedestals on the slab frame. The weight is transferred to the boxes through roller bearings.

The brake cylinder has been placed in front of the cylinders and operates a push rod passing through a cored passage in the saddle and connecting to an upright arm on the brake shaft.

The construction of the boiler is quite clearly shown in the illustrations and is especially notable for its unusual depth of firebox, particularly at the throat sheet. It will also be noticed that three 2-in. openings have been provided through each of the side water legs just above the level of the fire. These will admit considerable air from the outside and tend to improve combustion. A firebrick arch supported on four water tubes is to be installed. A single fire door 18 in. in diameter is provided. The boiler contains 268 2¼-in. tubes 19 ft. long, which give a heating surface of about 3,000 sq. ft., which together with the firebox and water tubes give a total heating surface of 3,200, or 70 sq. ft. per square foot of grate area. The ratio of 358 sq. ft. of heating surface per cubic foot volume equivalent simple cylinders indicates that the boiler should easily furnish sufficient steam to develop the full capacity of the engine at high speed.

The general weights, dimensions and ratios are as follows:

GENERAL DATA.

Gauge	4 ft. 8½ in.
Service	Passenger
Fuel	Bit. Coal
Tractive effort	22,200 lbs.
Weight in working order	205,350 lbs.
Weight on drivers	107,550 lbs.
Weight on leading truck	52,000 lbs.
Weight on trailing truck	45,800 lbs.
Weight of engine and tender in working order	340,000 lbs.
Wheel base, driving	7 ft. 6 in.
Wheel base, total	32 ft. 2 in.
Wheel base, engine and tender	63 ft. ½ in.

RATIOS.

Weight on drivers ÷ tractive effort	4.85
Total weight ÷ tractive effort	9.25
Tractive effort x diam. drivers ÷ heating surface	590.00
Total heating surface ÷ grate area	70.00
Firebox heating surface ÷ total heating surface, per cent	5.73
Weight on drivers ÷ total heating surface	33.50
Total weight ÷ total heating surface	64.50
Volume equiv. simple cylinders, cu. ft	8.90
Total heating surface ÷ vol. cylinders	358.00
Grate area ÷ vol. cylinders	5.15

CYLINDERS.

Kind	Bal. Compound
Diameter and stroke	15 & 25 x 28 in.
Kind of valves	Piston
Diameter of valves	15 in.

WHEELS.

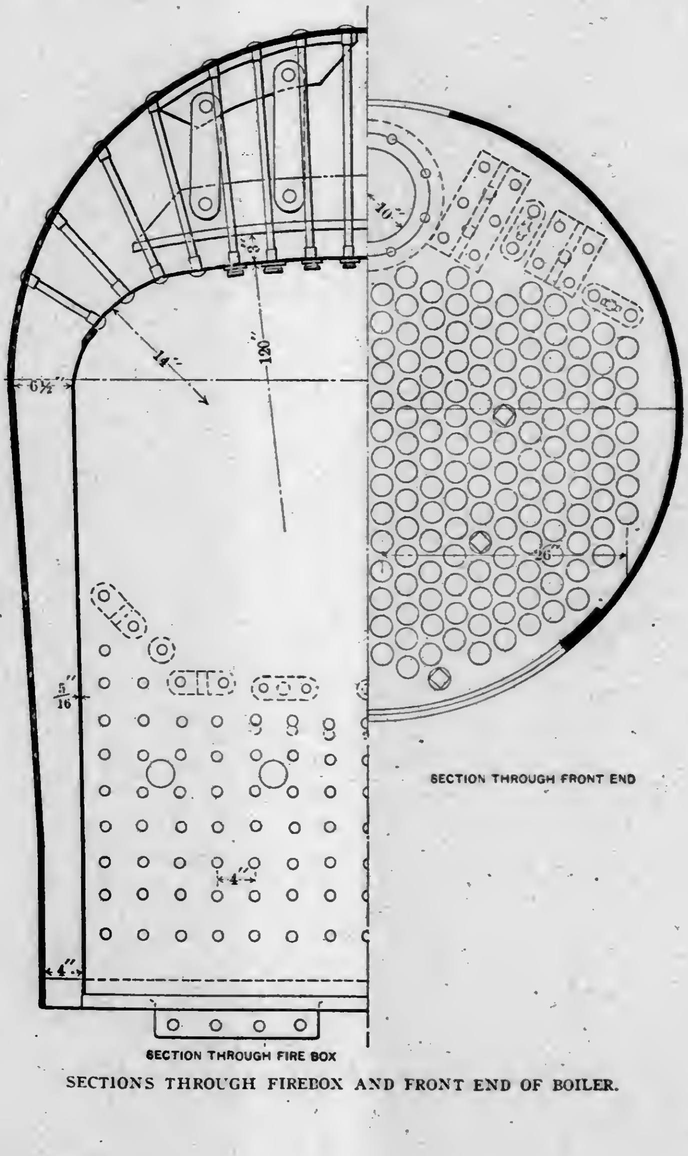
Driving, diameter over tires	85 in.
Driving, thickness of tires	3½ in.
Driving journals, main, diameter and length	10 x 11 in.
Driving journals, others, diameter and length	9 x 12 in.
Engine truck wheels, diameter	36 in.
Engine truck, journals	6 x 10 in.
Trailing truck wheels, diameter	49 in.
Trailing truck, journals	8½ x 14 in.

BOILER.

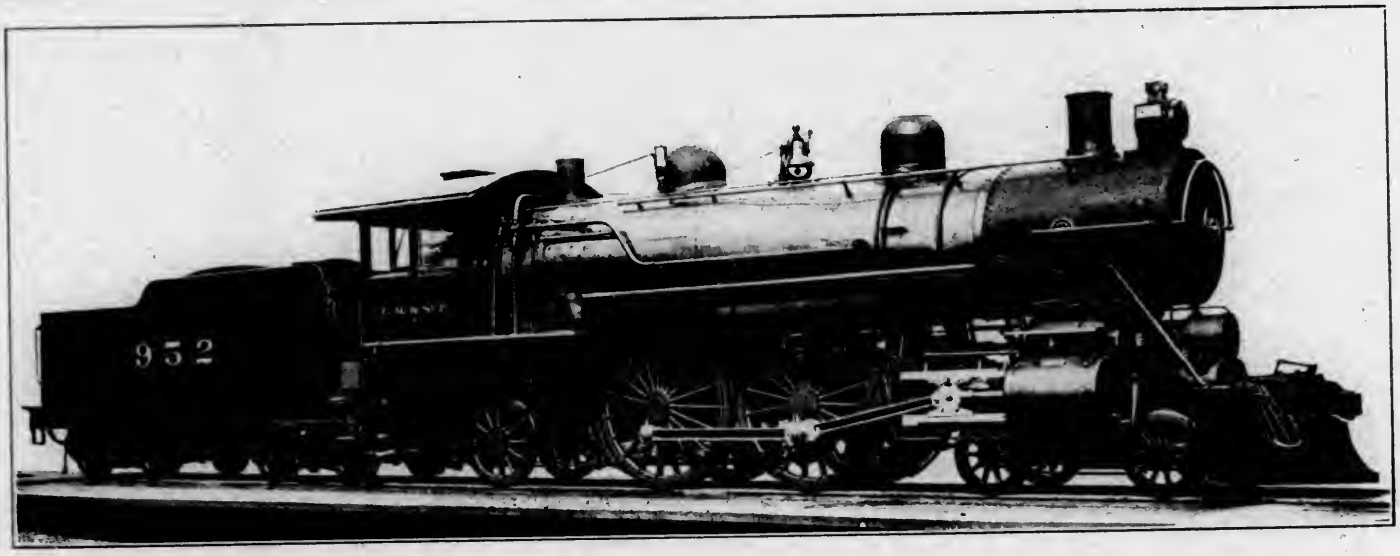
Style	Wagon Top
Working pressure	220 lbs.
Outside diameter of first ring	66 in.
Firebox, length and width	108 x 60⅛ in.
Firebox plates, thickness	5/16, ⅜ & ½ in.
Firebox, water space	F.-4, S. & B.-3½ in.
Tubes, number and outside diameter	268—2¼ in.
Tubes, length	19 ft.
Heating surface, tubes	3,015 sq. ft.
Heating surface, firebox	155 sq. ft.
Heating surface, arch tubes	28 sq. ft.
Heating surface, total	3,198 sq. ft.
Grate area	45.8 sq. ft.

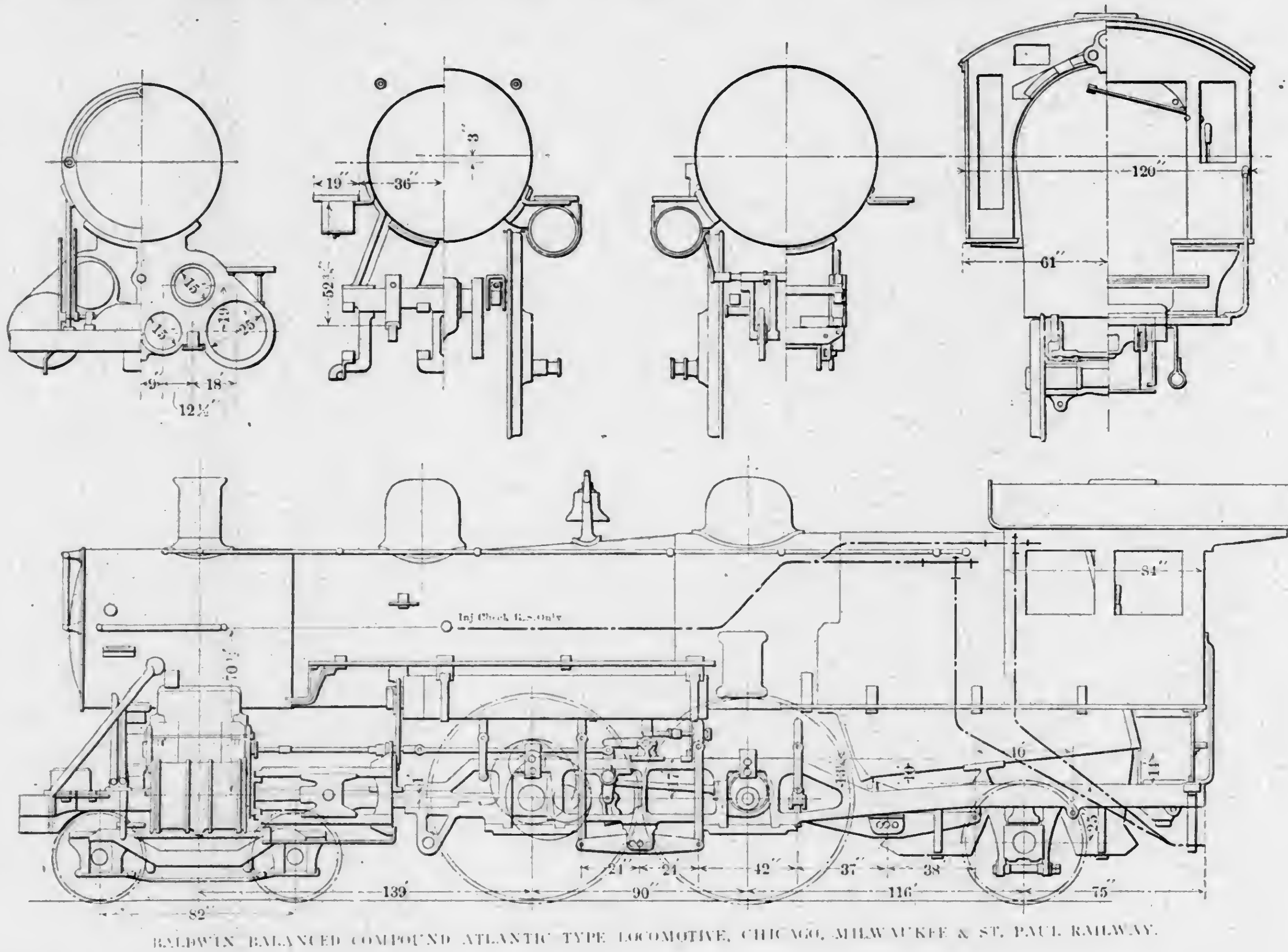
TENDER.

Wheels, diameter	38 in.
Journals, diameter and length	5 x 9 in.
Water capacity	7,000 gals.
Coal capacity	14 tons.



SECTIONS THROUGH FIREBOX AND FRONT END OF BOILER.





BALDWIN BALANCED COMPOUND ATLANTIC TYPE LOCOMOTIVE, CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.

BALANCED COMPOUND PASSENGER LOCOMOTIVES.

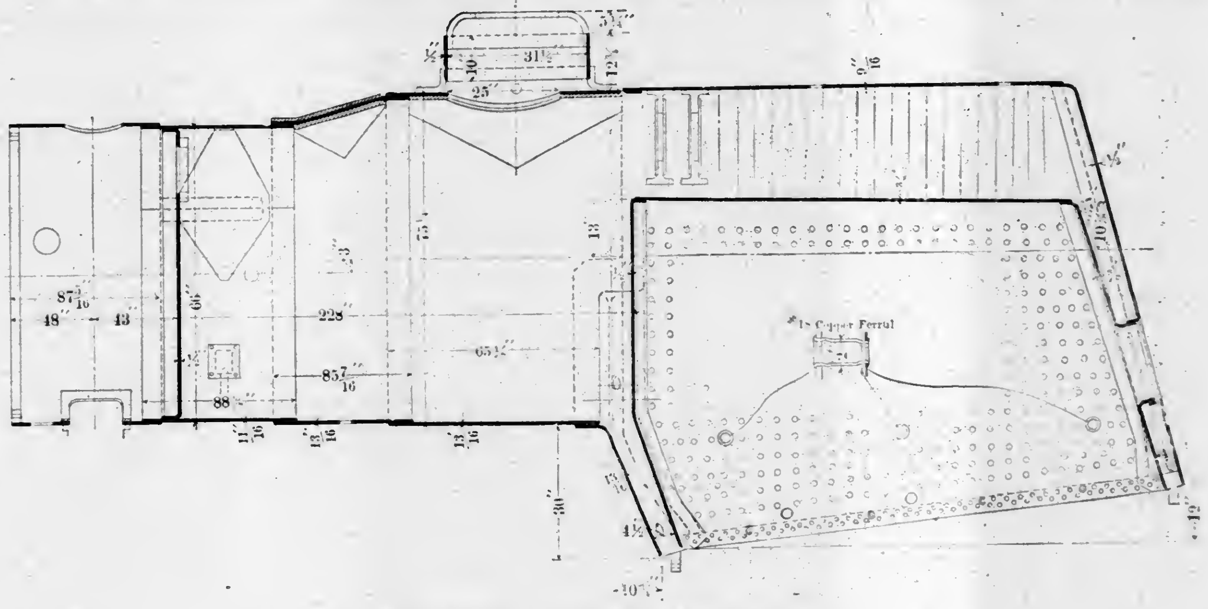
CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.

The Baldwin Locomotive Works has recently delivered two balanced compound Atlantic type locomotives to the Chicago, Milwaukee & St. Paul Railway, which are to be used in fast passenger service and have a tractive effort of 22,200 lbs. working compound.

These locomotives, as far as the arrangement of cylinders and running gear is concerned, do not differ in any essential features from most of the Baldwin compound locomotives of this type. The cylinders are set side by side in a horizontal line and all drive on the front pair of wheels; the cranked axle being of the built up type with a cast steel central web. The Stephenson type of valve gear is used, the eccentrics necessarily being on the rear driving axle. The link is located just back of the front axle and the rocker arm is so placed as to connect directly to the link block. The top of the rocker arm extends over the frame so as to connect directly to the valve rod, which passes along the top of the frame from this point to the 15-in. piston valve. This rod has a bearing in the guide yoke and is provided with a knuckle joint just back of this bearing.

The frames are of cast steel 4½ in. wide with single front frames of wrought iron. The DeVoy type of trailer truck* is used, which employs a trailer truck frame of the slab form 2¾ in. wide by 10 in. deep. The trailer truck boxes form part of a steel casting extending across the engine and are guided by

* See AMERICAN ENGINEER, April, 1905, pp. 135.



LONGITUDINAL SECTION THROUGH BOILER.

pedestals on the slab frame. The weight is transferred to the boxes through roller bearings.

The brake cylinder has been placed in front of the cylinders and operates a push rod passing through a cored passage in the saddle and connecting to an upright arm on the brake shaft.

The construction of the boiler is quite clearly shown in the illustrations and is especially notable for its unusual depth of firebox, particularly at the throat sheet. It will also be noticed that three 2-in. openings have been provided through each of the side water legs just above the level of the fire. These will admit considerable air from the outside and tend to improve combustion. A firebrick arch supported on four water tubes is to be installed. A single fire door 18 in. in diameter is provided. The boiler contains 268 2¼-in. tubes 19 ft. long, which give a heating surface of about 3,000 sq. ft., which together with the firebox and water tubes give a total heating surface of 3,200, or 70 sq. ft. per square foot of grate area. The ratio of 358 sq. ft. of heating surface per cubic foot volume equivalent simple cylinders indicates that the boiler should easily furnish sufficient steam to develop the full capacity of the engine at high speed.

The general weights, dimensions and ratios are as follows:

GENERAL DATA.

Gauge	4 ft. 8½ in.
Service	Passenger
Fuel	Bit. Coal
Tractive effort	22,200 lbs.
Weight in working order	205,350 lbs.
Weight on drivers	107,550 lbs.
Weight on leading truck	52,000 lbs.
Weight on trailing truck	45,800 lbs.
Weight of engine and tender in working order	340,000 lbs.
Wheel base, driving	7 ft. 6 in.
Wheel base, total	32 ft. 2 in.
Wheel base, engine and tender	63 ft. ½ in.

RATIOS.

Weight on drivers ÷ tractive effort	1.85
Total weight ÷ tractive effort	9.25
Tractive effort x diam. drivers ÷ heating surface	590.00
Total heating surface ÷ grate area	70.00
Firebox heating surface ÷ total heating surface, per cent	5.73
Weight on drivers ÷ total heating surface	33.50
Total weight ÷ total heating surface	64.50
Volume equiv. simple cylinders, cu. ft.	8.90
Total heating surface ÷ vol. cylinders	358.00
Grate area ÷ vol. cylinders	5.15

CYLINDERS.

Kind	Bal. Compound
Diameter and stroke	15 & 25 x 28 in.
Kind of valves	Piston
Diameter of valves	15 in.

WHEELS.

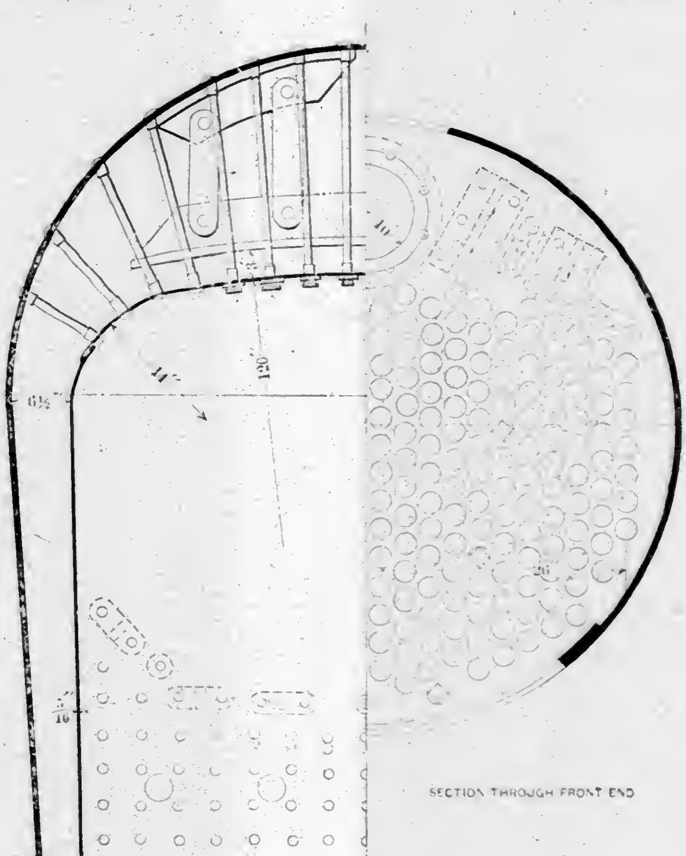
Driving, diameter over tires	85 in.
Driving, thickness of tires	3½ in.
Driving journals, main, diameter and length	10 x 11 in.
Driving journals, others, diameter and length	9 x 12 in.
Engine truck wheels, diameter	36 in.
Engine truck, journals	6 x 10 in.
Trailing truck wheels, diameter	49 in.
Trailing truck, journals	8½ x 14 in.

BOILER.

Style	Wagon Top
Working pressure	220 lbs.
Outside diameter of first ring	66 in.
Firebox, length and width	108 x 60⅛ in.
Firebox plates, thickness	5/16, ⅜ & ½ in.
Firebox, water space	F.-4, S. & B.-3½ in.
Tubes, number and outside diameter	268—2¼ in.
Tubes, length	19 ft.
Heating surface, tubes	3,015 sq. ft.
Heating surface, firebox	155 sq. ft.
Heating surface, arch tubes	28 sq. ft.
Heating surface, total	3,198 sq. ft.
Grate area	45.8 sq. ft.

TENDER.

Wheels, diameter	38 in.
Journals, diameter and length	5 x 9 in.
Water capacity	7,000 gals.
Coal capacity	14 tons.



SECTIONS THROUGH FIREBOX AND FRONT END OF BOILER.

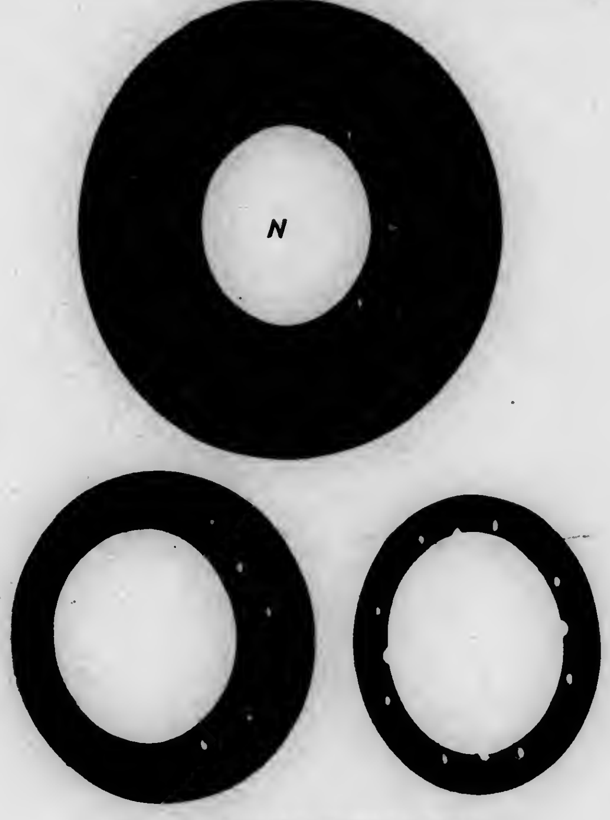


FIG. 2. CLAMP FOR GRINDING WHEEL.

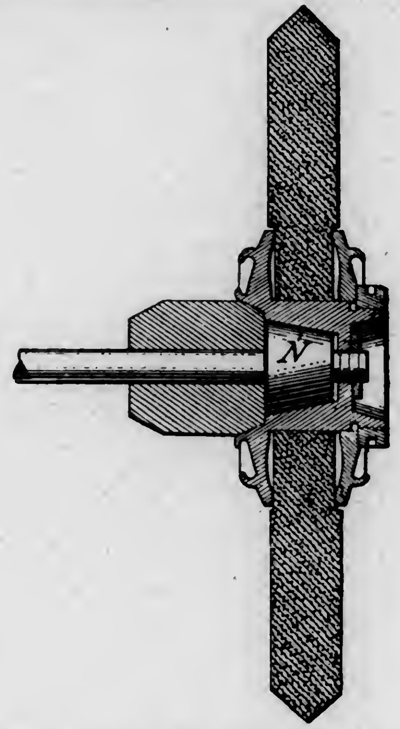


FIG. I. CLAMP FOR GRINDING WHEEL.

MONARCH CLAMPS FOR GRINDING WHEELS.

The emery and corundum wheels which are made by either the vitrified process, semi-vitrified or silicate process, and the elastic process, by the Monarch Emery & Corundum Wheel Company of Camden, N. J., are furnished in a great variety of shapes for use with the different makes and classes of grinding machines on the market. The two types of clamps illustrated were made especially for use with certain lines of grinding machines to replace the old method of cementing and yet not change the construction of the machine. They hold the wheels firmly and eliminate the annoyance caused by the loosening of wheels cemented on the spindle.

The clamp shown in Fig. 1 is used with a 24 x 2¾ in. wheel for the Sellers No. 1 tool grinder. The clamp consists of three parts. That portion which is recessed to fit the end of the spindle is held securely in place by a nut. The grinding wheel is slipped over this portion of the clamp and the loose flange is mounted in place and is secured in position by a lock nut. To change wheels it is only necessary to loosen the lock nut and take off the loose flange.

The clamp shown in Fig. 2 is used with a Sellers No. 2 universal tool grinder and is fastened to a disc on the end of the spindle. The main part of the clamp is recessed to fit this disc and is bolted to it. It is then only necessary to slip the wheel on to this part of the clamp and to fasten the removable rim or flange in place with set screws. To change the wheels this loose rim is loosened up and a new wheel put in place.

Output of Baldwin Locomotive Works.—The output of the Baldwin Works for the year 1907 exceeds the previous year by 84 and reaches a total of 2,750 locomotives.

Conditions Improving.—"Within a day or two we have received very decided indications that affairs are returning to a more normal condition. It looks as if the railroads are again about to place considerable new equipment orders, which they have not been doing for several months."—*Mr. A. B. Johnson on December 28.*

PERSONALS

Mr. C. F. Stevens has been appointed storekeeper of the Tonopah & Goldfield Ry., with office at Tonopah, Nev.

Mr. G. S. McKennon has been appointed assistant master mechanic of the Canadian Northern Ry. at Winnipeg, Man.

Mr. C. B. Gifford, master mechanic of the Louisville & Nashville R. R. at Mobile, Ala., has resigned, to retire from railroad business.

Mr. N. L. Smitham has been appointed master mechanic of the Texas Midland Ry. at Terrell, Texas, succeeding Mr. O. W. Lewis, resigned.

Mr. H. A. Rouse, storekeeper of the Chicago & Alton R. R., has had his jurisdiction extended to include the Toledo, St. Louis & Western Ry.

Mr. D. D. Briggs has been appointed master mechanic of the Louisville & Nashville R. R. at Mobile, Ala., succeeding Mr. C. B. Gifford, resigned.

Mr. J. P. Jackson, professor of electrical engineering, Pennsylvania State College, has been appointed dean of the School of Engineering at the same place.

Mr. O. M. Foster, assistant master mechanic of the Lake Shore & Michigan Southern Ry. at Elkhart, Ind., has been promoted to master mechanic at the same point.

Mr. A. O. Berry, general foreman of the Collinwood shops of the Lake Shore & Michigan Southern Ry., has been appointed superintendent of shops at Elkhart, Ind.

Mr. T. O. Sechrist, master mechanic of the Alabama Great Southern Ry. at Chattanooga, Tenn., has been transferred to Somerset, Ky., vice Mr. Dooley, transferred.

Mr. A. R. Ayres, superintendent of shops of the Lake Shore and Michigan Southern Ry. at Elkhart, Ind., has been appointed assistant superintendent of shops at Collinwood, O.

Mr. F. R. Doxey has been appointed master mechanic of the Des Moines, Iowa Falls & Northern R. R. at Iowa Falls, Ia.

Mr. F. W. Schultz has been appointed master mechanic of the Missouri Pacific Ry. and St. Louis, Iron Mountain & Southern Ry. at McGehee, Ark., in place of Mr. I. T. Johns, resigned.

Mr. J. T. Carroll, assistant superintendent of shops of the Lake Shore & Michigan Southern Railway at Collinwood, O., has been appointed assistant master mechanic at Elkhart, Ind.

Mr. Chandler C. Coats, who was master mechanic of the New York & Philadelphia division of the Pennsylvania Railroad for 40 years, died at his home in Newark, N. J., December 2, aged 82 years.

Mr. J. L. Kendrick has been promoted to the position of foreman of the mechanical department of the Buffalo, Rochester & Pittsburg Railway at Punxsutawney, Pa., succeeding Mr. W. H. Williams, promoted.

Mr. J. Quigby, general foreman of the Somerset shops of the Alabama Great Southern Ry., has been promoted to master mechanic of the Chattanooga division at Chattanooga, Tenn., vice Mr. Sechrist, transferred.

Mr. W. H. Williams has been appointed master mechanic of the Buffalo & Rochester division of the Buffalo, Rochester & Pittsburg R. R., with headquarters at East Salamanca, N. Y., vice Mr. H. C. Woodbridge, transferred.

Mr. Charles P. Matthews, professor of electrical engineering at Purdue University, died at Phoenix, Ariz., November 23, 1907, age 40 years. Professor Matthews was widely known for his researches in photometric standards for arc lamps.

Mr. M. J. McCarthy, master mechanic of the Lake Shore & Michigan Southern Ry. at Elkhart, Ind., has been appointed master mechanic of the new Beach Grove shops of the Cleveland, Cincinnati, Chicago & St. Louis Ry., near Indianapolis, Ind.

Mr. William Walter, formerly master mechanic of the Chicago, Milwaukee & St. Paul Ry. at Dubuque, Iowa, has been appointed master mechanic of one of the new divisions of the extension to the Pacific coast, with headquarters at Mobridge, S. D.

Mr. Sanford G. Scarritt, president of the Scarritt-Comstock Furniture Co. of St. Louis died on December 7, 1907. Mr. Scarritt was one of the founders of this company and was treasurer of the St. Louis Railroad Club for many years. He was formerly for many years connected with Mr. N. M. Forney in the development of car seats.

Mr. Storm Bull, professor of steam engineering in the University of Wisconsin, Madison, Wis., died November 18. Prof. Bull was born at Bergen, Norway, October 20, 1856, and was graduated from the Federal Swiss Polytechnic Institute at Zurich with the degree of Mechanical Engineering in 1877. He came to this country, and in 1879 became an instructor in mechanical engineering at the University of Wisconsin. In 1884 he became assistant professor, and in 1886 was made professor of mechanical engineering. He held this position until 1890, when he was appointed professor of steam engineering.

BOOKS

Tests of Reinforced Concrete. Bulletin No. 14, series of 1906, published and issued by the University of Illinois, Engineering Experiment Station. L. P. Breckenridge, Director, Urbana, Ill.

This bulletin describes tests made as a continuation of those described in bulletin No. 4. The topics investigated include the effect of the quality of concrete upon the strength of beams and the effect of repetitive loading and the resistance to diagonal tension failures.

Old Steam Boat Days on the Hudson. By David Buckman. Cloth. 5½ x 8. 136 pages. Illustrated. Published by the Grafton Press, 70 Fifth Avenue, New York. Price, $1.25 net.

The approaching dual celebration of the ter-centennial of the discovery of the Hudson River and the centennial of Fulton's application of steam to navigation on the same river, has led to the incorporation of many interesting stories of the early steamboat days on the Hudson River into one volume. It is very profusely illustrated with views of the early steam crafts, as well as the floating palaces which are now in operation.

Mechanical World Pocket Diary and Year Book for 1908. Pocket size. 4¼ x 6¼. 296 pages. Published by Emott & Co., Ltd., 65 King Street, Manchester, England. Price, 15c., net.

This is the twenty-first year of publication of this well-known pocket diary and year book, which is filled with useful engineering notes, rules, tables and data. It has been completely revised and new sections introduced, old ones re-written and the whole matter brought strictly up to date. The section on electrical transmission of power has been omitted and is being incorporated in another book of similar shape. About 60 blank pages arranged with the days for the year 1908, which can be used for a memorandum and diary, are included.

Proceedings of the International Railroad Master Blacksmiths' Association. Fifteenth Annual Convention, 1907. Edited by A. L. Woodworth. Cloth. 6 x 8 in. 244 pages. Published by the Association, A. L. Woodworth, Secretary, Lima, Ohio.

The 1907 convention of this Association, held in Montreal, Canada, Aug. 21-23, was taken up by the consideration of the usual number of valuable reports and papers. The following subjects were discussed: Tools and Formers for Bulldozers and Steam Hammers; Discipline and Classification of Work; Flue Welding; Case Hardening; Fuel; Piece Work; Frame Making; Thermit Welding and Patch Bolts. A number of the most valuable reports presented at former conventions are reprinted in this volume. The next convention will be held in Cincinnati.

Railway Shop Up to Date. Compiled by the Editorial Staff of the *Railway Master Mechanic*. Maham H. Haig managing editor, and B. W. Benedict, editor. Cloth. 9 x 12. 243 pages. Published by the Crandall Publishing Company, Security Building, Chicago. Price, $4.00.

While the location of the buildings or arrangement of machine tools of a large railway repair shop can never be reduced to a standard, nor is it possible to design the different structures by the unit system, so as to be applicable to shops of all capacities, still what has already been constructed is often of great benefit in deciding upon the best arrangement and design of a new shop. It is also true that while a certain form of structure and interrelation of different departments is perfectly successful in one locality and with one kind of labor, it will not be at all successful under other circumstances. Nevertheless, it is often possible, with slight modifications, to so adapt an arrangement, which is subject to conditions similar to those holding at the place under consideration, that it will be perfectly satisfactory. It is for the purpose of making such information easily available that this book has been compiled, and while practically all of the matter contained therein has appeared in one or more of the technical journals at various times during the past six or eight years, this is the first attempt that has been made, on a large scale, to collect it within one volume.

The work confines itself to the physical characteristics of railway repair shops and opens with a discussion of the layout of a plant, in which the general governing conditions are briefly discussed, each structure being taken up separately. This is followed by a brief investigation of quite a large number of individual repair plants, including both locomotive and car shops.

Line drawings showing the general layout of twenty-one representative shops, either rebuilt or newly constructed during the past ten years, complete the chapter. The remaining chapters take up the different individual shops in the plant, giving first a general discussion of the subject with an investigation of the advantages and disadvantages of various arrangements and construction, which in each case is followed by illustrations of the buildings devoted to these purposes at a large number of plants. Such chapters include the locomotive shop, in which is given the layout of the machine tools and machine tool list for several shops; the blacksmith shop; freight car shop; coach and paint shop; planing mill; foundry; power plant; store-house and roundhouse, including coal and ash-handling plants.

The book is concluded by a list of references to shop descriptions which have appeared in the various technical journals since 1900. A comprehensive and complete index is included.

The Car Wheel. Giving the Results of a Series of Investigations by Mr. Geo. L. Fowler, M. E. Bound in boards; 5 x 9; 161 pages; illustrated. Published for private distribution by the Schoen Steel Wheel Company, Pittsburg, Pa.

While president of the Pressed Steel Car Company, Mr. Chas. T. Schoen was confronted with the difficult problem of obtaining wheels which would meet the requirements of 100,000-lb. capacity cars, particularly on mountain roads with steep grades and sharp curves. The situation was so serious that for a while it seemed as if it was going to be impossible to operate cars of this capacity except in special cases, owing to the fact that the failures of cast iron wheels were so numerous. Mr. Schoen decided that the requirements demanded something better than even a much improved cast iron wheel and that it would be absolutely necessary to use some kind of steel wheels under high capacity freight cars, as well as passenger coaches, if the full benefit of this equipment was to be obtained. The cost of the steel tired wheels made them prohibitive for this service and hence attention was turned to the developing of a solid forged and rolled steel wheel. The first of these wheels were designed in 1901, and in 1903 the business was established on a commercial basis. Since that time the enterprise has been a success and at present this company has a plant in operation in this country capable of producing 250,000 wheels per year, as well as a plant in England with a capacity of 100,000 wheels.

Actuated by a desire to know exactly what were the requirements to be met by car wheels in the most difficult service, this company retained Mr. George L. Fowler, consulting mechanical engineer, New York, to make a complete investigation of the stresses occurring in car wheels, particularly at the flange, as well as the quantity of metal and workmanship necessary to give a satisfactory wheel, both in regard to strength and wearing qualities. This work has been carried out very carefully and results have been obtained which will be of great benefit to the railways. These are now given publicity through the medium of this book.

Most of the tests made are comparative between solid forged and rolled steel wheels, steel tired and cast iron wheels. All of the tests were made upon wheels bought in the open market, chosen at random and tested under identical conditions. These investigations covered a period of over two years and tests and studies were made on the lateral thrust of wheels against the rail, the comparative physical and chemical properties of the material, the heat treatment and penetration of physical work in rolling the metal and co-efficient of friction between the wheel and rail, both sliding and slipping. The report of each test is very complete, the methods used and results obtained being clearly explained, tables being put into graphical form wherever possible. The illustrations are reproduced on heavy plate paper and pasted on blank pages of the book, and give results as good or better than actual photographs. The results are presented impartially and the value of the data given cannot be exaggerated.

The book itself is an excellent example of the bookmaker's art, being printed on heavy vellum paper with illuminated chapter headings. It is bound in boards with embossed gold title letters.

CATALOGS

IN WRITING FOR THESE PLEASE MENTION THIS JOURNAL.

Thermit Welding.—The Goldschmidt Thermit Co., 90 West street, New York, is issuing a reprint, from the journal of the U. S. Artillery, of an article on the possibilities of quick repairs on heavy ordnance by thermit welding processes. A number of excellent illustrations, showing the possibilities of this compound for use on ordnance and steamship work are included.

Gre-solvent.—The Utility Company, 636 West 44th street, New York City, has furnished samples of a paste compound manufactured by it and known as "Gre-solvent." Will quickly dissolve and remove from the hands all manner of machine grease, grime, paint, printers' ink, etc. Is said not to injure the most sensitive skin and to be practically as cheap as soap. It is understood that free samples will be mailed on request.

Grinding Wheels and Machinery.—The Norton Co., Worcester, Mass., is issuing a small catalog which includes a table showing the grade of grinding wheels required for different kinds of work. These are manufactured of alundum in twenty-six different grades, each of which is adapted to special purposes. Illustrations and brief descriptions of a few grinding machines and a price list of wheels are included.

Machine Tools.—Catalog No. 45 from the Newton Machine Tool Works, Philadelphia, Pa., illustrates and briefly describes their general line of machine tools. It contains over 300 pages, is 6 by 9 in. in size and is neatly and substantially bound in cloth. The machines described cover the following lines: milling machines, boring machines, cold saw cutting off machines, drilling machines, shaping machines, crank planers, gear cutting machines, nut machines, rotary planing machines, also a number of miscellaneous machines.

Pipe and Boiler Lagging.—The Philip Carey Co., Cincinnati, O., is issuing an attractive catalog entitled "Carey's Coverings." This illustrates many different types of coverings for steam and air pipes, magnesia boiler lagging, magnesia cement, mineral wool, hair felt, asbestos products, etc. Many excellent photographs of installations are also included. The covering for steam pipes and boilers are absolutely fireproof and the most thorough non-conductors of heat. These laggings are light in weight and are furnished in sizes and shapes to suit any requirements.

Electrical Apparatus.—The General Electric Company is issuing a number of new bulletins describing the latest improvements in several of its different products. One of these is on the subject of portable instruments, which are claimed to be permanently accurate and capable of giving accurate indications in the vicinity of external magnetic fields. Another bulletin covers single phase motors of moderate capacities. It illustrates various sizes, describes the details of construction and operation, shows forms of starting boxes and gives a large amount of general information useful and important to power users. These motors are well adapted to the operation of all kinds of machines and may be direct connected to loads requiring a moderate starting torque. Other bulletins are being issued on the subject of meter testing, direct current instruments, and concentric and inverted diffusers.

Speed Indicator.—Harry Vissering, Chicago, is issuing an attractive catalog illustrating the Hausshalter speed, time and distance indicator and recorder. This apparatus is adapted for use on locomotives or cars and in addition to indicating the speed of the train by means of a hand on the dial, it also automatically records on a record tape the speed at all times, the time between stops, time of stops, distance of stops from terminal, time and rate of accelerating or retarding, distance between stations or stops, total distance and time of run. This record, as can easily be seen, would prove of great value to the transportation department. The record tape is located within the case of the instrument and can only be removed by the proper authority. The construction and arrangement of the apparatus is clearly explained by many line drawings, halftone views and carefully written type matter. Sample record tapes and illustrations of the proper method of attaching the instrument to the locomotive or car are included. This instrument will do all that the Boyer speed recorder will and gives many other valuable records in addition.

NOTES

Refined Iron & Steel Company.—This company announces that it has not been compelled to close down its mill because of the financial stringency as has been found necessary with a number of other plants in the Pittsburg district, but that on the contrary it has been compelled to run double turn in its finishing mills for several weeks.

American Locomotive Company.—Among the orders recently received by this company are three consolidation locomotives for the Western Railway of Havana, cylinders 20 x 24 in.; two Mogul locomotives for the Northwestern Pacific Railway, cylinders 18 x 24, and fiv[illegible]n wheel locomotives for L. J. Smith, with 19 x 28 in. cylinders.

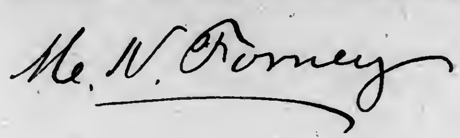
MATTHIAS NACE FORNEY.

Matthias Nace Forney died Tuesday, January 14, at the Hotel Buckingham, New York City, after a first attack of paralysis. He was buried at Hanover, Pa.

Very few men have exerted so great an influence on the upbuilding of our railroads, and none more than Mr. Forney. A large part of his most important and effective work was done a generation ago and it is impossible to realize fully the far-reaching importance of some of it without understanding the conditions as they then existed. In the "battle of the gauges," in the early seventies, Mr. Forney, at that time editor of the *Railroad Gazette*, fought almost alone, at the beginning, against the general adoption of the narrow gauge and was finally successful in turning the tide. He was very active in the Master Car Builders' and Master Mechanics' Associations; the reorganization of the Master Car Builders' Association, placing it on a representative basis, for which he was largely responsible, has resulted in the standardizing of freight equipment so that cars may be interchanged over the railroads on the continent. He was active in advocating the adoption of elevated railways in New York City and for many years the Forney type locomotive was used exclusively on these roads, prior to the adoption of electricity. He was largely instrumental in gathering together and arranging the information in the first editions of the Master Car Builders' Dictionary. It is impossible to estimate the influence of his clear-cut, far-sighted, common-sense views advanced in connection with his journalistic work, when technical journalism was in its infancy; nor can the far-reaching results of such a work as his "Locomotive Catechism" be computed.

His character can best be summed up in a paragraph taken from an editorial notice in the *Railroad Gazette*, written by Mr. S. W. Dunning, who was associated with him for many years on that paper:

"To us who knew Mr. Forney intimately, the character of the man overshadows all accomplishments and performances. He not only did justly, but he was willing to spend and be spent that justice might be done. He loved mercy, and he labored that the weak and helpless should be mercifully dealt with. In the later years of his life he gave a great deal of work and was at considerable expense to secure better treatment of horses—creatures with which personally he had little more to do than with elephants. Believing that material political progress is to be hoped for from minority representation he published at his own expense a book on the subject, containing, with much else, the substance of other works then out of print. In many similar ways he demonstrated his public spirit, his humanity and his unselfishness. No one could more truly say: '*Write me as one who loves his fellow-men.*'"



Mr. Forney was born in Hanover, York Co., Pennsylvania, on March 28, 1835. His father, after whom he was named, died March 25, 1857, leaving his mother with the care of three sons and three daughters.

The schools in Hanover in those days were taught by teachers of more or less itinerate habit, and in the words of Mr. Forney "knowledge had to be assimilated from much indigestible food." He had this to say of his early life: "Very early in life mechanism and science interested me very much. It gave me great pleasure to decorate the top of our woodshed with miniature wind-mills, to construct water-wheels which were driven by the stream from a spring near the house, and to make toy cannons out of anything which would hold a charge of powder. My great ambition was to build a small steam engine, but for that my mechanical resources were not adequate, although I made a number of attempts in that direction. Tools and machinery were my delight then, and have been ever since. I then always had a workshop which was very poorly equipped with carpenter's tools, but it was a source of endless pleasure to me. My first ambition was to be a shipbuilder, then steam-engines took hold of my imagination and finally locomotives got possession of me and have absorbed much of my time and thoughts ever since."

At fourteen years of age he was sent to a boys' school in Baltimore, where he remained for three winters. In April, 1852, he entered the shop of Ross Winans as an apprentice. Mr. Winans was then engaged in building locomotives in Baltimore, chiefly for the Baltimore & Ohio Railroad. Three years were spent in the shop and one in the drawing room. His next position was that of draftsman in the shops of the Baltimore & Ohio Railroad, where he continued for about three years. As the prospect of advancement did not seem very good he entered the mercantile business in about 1858, where he remained until the outbreak of the civil war in 1861.

His business ventures up to that time had not been successful. Business in Baltimore was more or less disturbed, and after trying several different occupations he took a position as draftsman in the machinery department of the Illinois Central Railroad in Chicago. It was while in this position that he designed what afterwards became known as the "Forney engine," but because of delays in the patent office the patent was not issued until 1866. He remained with the Illinois Central for about three years, after which he took a position for a short time as draftsman with the Detroit Bridge & Iron Works. In the spring of 1865 he received an appointment from the president of the Illinois Central Railroad Company to superintend the building of some locomotives at the Hinckley & Williams Works in Boston. This work occu-

Line drawings showing the general layout of twenty-one representative shops, either rebuilt or newly constructed during the past ten years, complete the chapter. The remaining chapters take up the different individual shops in the plant, giving first a general discussion of the subject with an investigation of the advantages and disadvantages of various arrangements and construction, which in each case is followed by illustrations of the buildings devoted to these purposes at a large number of plants. Such chapters include the locomotive shop, in which is given the layout of the machine tools and machine tool list for several shops; the blacksmith shop; freight car shop; coach and paint shop; planing mill; foundry; power plant; store-house and roundhouse, including coal and ash-handling plants.

The book is concluded by a list of references to shop descriptions which have appeared in the various technical journals since 1900. A comprehensive and complete index is included.

The Car Wheel. Giving the Results of a Series of Investigations by Mr. Geo. L. Fowler, M. E. Bound in boards; 5 x 9; 161 pages; illustrated. Published for private distribution by the Schoen Steel Wheel Company, Pittsburg, Pa.

While president of the Pressed Steel Car Company, Mr. Chas. T. Schoen was confronted with the difficult problem of obtaining wheels which would meet the requirements of 100,000-lb. capacity cars, particularly on mountain roads with steep grades and sharp curves. The situation was so serious that for a while it seemed as if it was going to be impossible to operate cars of this capacity except in special cases, owing to the fact that the failures of cast iron wheels were so numerous. Mr. Schoen decided that the requirements demanded something better than even a much improved cast iron wheel and that it would be absolutely necessary to use some kind of steel wheels under high capacity freight cars, as well as passenger coaches, if the full benefit of this equipment was to be obtained. The cost of the steel tired wheels made them prohibitive for this service and hence attention was turned to the developing of a solid forged and rolled steel wheel. The first of these wheels were designed in 1901, and in 1903 the business was established on a commercial basis. Since that time the enterprise has been a success and at present this company has a plant in operation in this country capable of producing 250,000 wheels per year, as well as a plant in England with a capacity of 100,000 wheels.

Actuated by a desire to know exactly what were the requirements to be met by car wheels in the most difficult service, this company retained Mr. George L. Fowler, consulting mechanical engineer, New York, to make a complete investigation of the stresses occurring in car wheels, particularly at the flange, as well as the quantity of metal and workmanship necessary to give a satisfactory wheel, both in regard to strength and wearing qualities. This work has been carried out very carefully and results have been obtained which will be of great benefit to the railways. These are now given publicity through the medium of this book.

Most of the tests made are comparative between solid forged and rolled steel wheels, steel tired and cast iron wheels. All of the tests were made upon wheels bought in the open market, chosen at random and tested under identical conditions. These investigations covered a period of over two years and tests and studies were made on the lateral thrust of wheels against the rail, the comparative physical and chemical properties of the material, the heat treatment and penetration of physical work in rolling the metal and co-efficient of friction between the wheel and rail, both sliding and slipping. The report of each test is very complete, the methods used and results obtained being clearly explained, tables being put into graphical form wherever possible. The illustrations are reproduced on heavy plate paper and pasted on blank pages of the book, and give results as good or better than actual photographs. The results are presented impartially and the value of the data given cannot be exaggerated.

The book itself is an excellent example of the bookmaker's art, being printed on heavy vellum paper with illuminated chapter headings. It is bound in boards with embossed gold title letters.

CATALOGS

THERMIT WELDING. The Goldschmidt Thermit Co., 90 West street, New York, is issuing a reprint, from the journal of the U. S. Artillery, of an article on the possibilities of quick repairs on heavy ordnance by thermit welding processes. A number of excellent illustrations, showing the possibilities of this compound for use on ordnance and steamship work are included.

GRE-SOLVENT.—The Utility Company, 636 West 44th street, New York City, has furnished samples of a paste compound manufactured by it and known as "Gre-solvent." Will quickly dissolve and remove from the hands all manner of machine grease, grime, paint, printers' ink, etc. Is said not to injure the most sensitive skin and to be practically as cheap as soap. It is understood that free samples will be mailed on request.

GRINDING WHEELS AND MACHINERY.—The Norton Co., Worcester, Mass., is issuing a small catalog which includes a table showing the grade of grinding wheels required for different kinds of work. These are manufactured of alundum in twenty-six different grades, each of which is adapted to special purposes. Illustrations and brief descriptions of a few grinding machines and a price list of wheels are included.

MACHINE TOOLS.—Catalog No. 45 from the Newton Machine Tool Works, Philadelphia, Pa., illustrates and briefly describes their general line of machine tools. It contains over 300 pages, is 6 by 9 in. in size and is neatly and substantially bound in cloth. The machines described cover the following lines: milling machines, boring machines, cold saw cutting off machines, drilling machines, shaping machines, crank planers, gear cutting machines, nut machines, rotary planing machines, also a number of miscellaneous machines.

PIPE AND BOILER LAGGING.—The Philip Carey Co., Cincinnati, O., is issuing an attractive catalog entitled "Carey's Coverings." This illustrates many different types of coverings for steam and air pipes, magnesia boiler lagging, magnesia cement, mineral wool, hair felt, asbestos products, etc. Many excellent photographs of installations are also included. The coverings for steam pipes and boilers are absolutely fireproof and the most thorough non-conductors of heat. These laggings are light in weight and are furnished in sizes and shapes to suit any requirements.

ELECTRICAL APPARATUS.—The General Electric Company is issuing a number of new bulletins describing the latest improvements in several of its different products. One of these is on the subject of portable instruments, which are claimed to be permanently accurate and capable of giving accurate indications in the vicinity of external magnetic fields. Another bulletin covers single phase motors of moderate capacities. It illustrates various sizes, describes the details of construction and operation, shows forms of starting boxes and gives a large amount of general information useful and important to power users. These motors are well adapted to the operation of all kinds of machines and may be direct connected to loads requiring a moderate starting torque. Other bulletins are being issued on the subject of meter testing, direct current instruments, and concentric and inverted diffusers.

SPEED INDICATOR.—Harry Vissering, Chicago, is issuing an attractive catalog illustrating the Hausshalter speed, time and distance indicator and recorder. This apparatus is adapted for use on locomotives or cars and in addition to indicating the speed of the train by means of a hand on the dial, it also automatically records on a record tape the speed at all times, the time between stops, time of stops, distance of stops from terminal, time and rate of accelerating or retarding, distance between stations or stops, total distance and time of run. This record, as can easily be seen, would prove of great value to the transportation department. The record tape is located within the case of the instrument and can only be removed by the proper authority. The construction and arrangement of the apparatus is clearly explained by many line drawings, halftone views and carefully written type matter. Sample record tapes and illustrations of the proper method of attaching the instrument to the locomotive or car are included. This instrument will do all that the Boyer speed recorder will and gives many other valuable records in addition.

NOTES

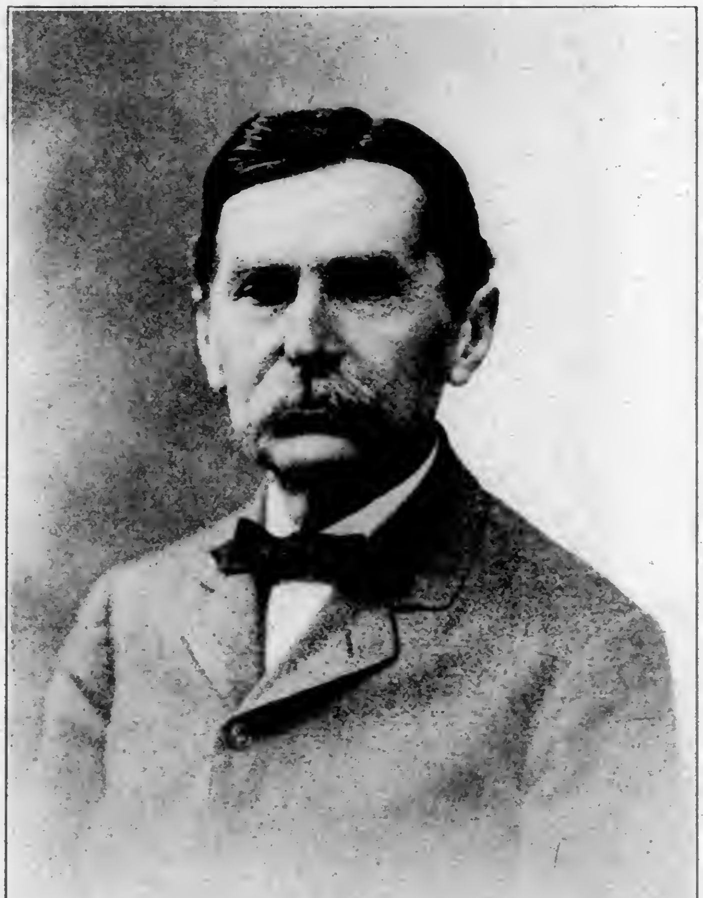
REFINED IRON & STEEL COMPANY. This company announces that it has not been compelled to close down its mill because of the financial stringency as has been found necessary with a number of other plants in the Pittsburg district, but that on the contrary it has been compelled to run double turn in its finishing mills for several weeks.

AMERICAN LOCOMOTIVE COMPANY. Among the orders recently received by this company are three consolidation locomotives for the Western Railway of Havana, cylinders 20 x 24 in.; two Mogul locomotives for the Northwestern Pacific Railway, cylinders 18 x 24, and fiv[illegible]n wheel locomotives for L. J. Smith, with 19 x 28 in. cylinders.

MATTHIAS NACE FORNEY.

Matthias Nace Forney died Tuesday, January 14, at the Hotel Buckingham, New York City, after a first attack of paralysis. He was buried at Hanover, Pa.

Very few men have exerted so great an influence on the upbuilding of our railroads, and none more than Mr. Forney. A large part of his most important and effective work was done a generation ago and it is impossible to realize fully the far-reaching importance of some of it without understanding the conditions as they then existed. In the "battle of the gauges," in the early seventies, Mr. Forney, at that time editor of the *Railroad Gazette,* fought almost alone, at the beginning, against the general adoption of the narrow gauge and was finally successful in turning the tide. He was very active in the Master Car Builders' and Master Mechanics' Associations; the reorganization of the Master Car Builders' Association, placing it on a representative basis, for which he was largely responsible, has resulted in the standardizing of freight equipment so that cars may be interchanged over the railroads on the continent. He was active in advocating the adoption of elevated railways in New York City and for many years the Forney type locomotive was used exclusively on these roads, prior to the adoption of electricity. He was largely instrumental in gathering together and arranging the information in the first editions of the Master Car Builders' Dictionary. It is impossible to estimate the influence of his clear-cut, far-sighted, common-sense views advanced in connection with his journalistic work, when technical journalism was in its infancy; nor can the far-reaching results of such a work as his "Locomotive Catechism" be computed.



M. N. Forney

His character can best be summed up in a paragraph taken from an editorial notice in the *Railroad Gazette,* written by Mr. S. W. Dunning, who was associated with him for many years on that paper:

"To us who knew Mr. Forney intimately, the character of the man overshadows all accomplishments and performances. He not only did justly, but he was willing to spend and be spent that justice might be done. He loved mercy, and he labored that the weak and helpless should be mercifully dealt with. In the later years of his life he gave a great deal of work and was at considerable expense to secure better treatment of horses—creatures with which personally he had little more to do than with elephants. Believing that material political progress is to be hoped for from minority representation he published at his own expense a book on the subject, containing, with much else, the substance of other works then out of print. In many similar ways he demonstrated his public spirit, his humanity and his unselfishness. No one could more truly say: *'Write me as one who loves his fellow-men.'* "

Mr. Forney was born in Hanover, York Co., Pennsylvania, on March 28, 1835. His father, after whom he was named, died March 25, 1857, leaving his mother with the care of three sons and three daughters.

The schools in Hanover in those days were taught by teachers of more or less itinerate habit, and in the words of Mr. Forney "knowledge had to be assimilated from much indigestible food." He had this to say of his early life: "Very early in life mechanism and science interested me very much. It gave me great pleasure to decorate the top of our woodshed with miniature wind-mills, to construct water-wheels which were driven by the stream from a spring near the house, and to make toy cannons out of anything which would hold a charge of powder. My great ambition was to build a small steam engine, but for that my mechanical resources were not adequate, although I made a number of attempts in that direction. Tools and machinery were my delight then, and have been ever since. I then always had a workshop which was very poorly equipped with carpenter's tools, but it was a source of endless pleasure to me. My first ambition was to be a shipbuilder, then steam-engines took hold of my imagination and finally locomotives got possession of me and have absorbed much of my time and thoughts ever since."

At fourteen years of age he was sent to a boys' school in Baltimore, where he remained for three winters. In April, 1852, he entered the shop of Ross Winans as an apprentice. Mr. Winans was then engaged in building locomotives in Baltimore, chiefly for the Baltimore & Ohio Railroad. Three years were spent in the shop and one in the drawing room. His next position was that of draftsman in the shops of the Baltimore & Ohio Railroad, where he continued for about three years. As the prospect of advancement did not seem very good he entered the mercantile business in about 1858, where he remained until the outbreak of the civil war in 1861.

His business ventures up to that time had not been successful. Business in Baltimore was more or less disturbed, and after trying several different occupations he took a position as draftsman in the machinery department of the Illinois Central Railroad in Chicago. It was while in this position that he designed what afterwards became known as the "Forney engine," but because of delays in the patent office the patent was not issued until 1866. He remained with the Illinois Central for about three years, after which he took a position for a short time as draftsman with the Detroit Bridge & Iron Works. In the spring of 1865 he received an appointment from the president of the Illinois Central Railroad Company to superintend the building of some locomotives at the Hinckley & Williams Works in Boston. This work occu-

pied about six months, after which he entered the employ of Hinckley & Williams, partly as a draftsman and partly as a traveling agent. He remained with them about three years. During the last year of that time his office and headquarters were in New York and when his engagement with the company was ended he spent a year or more in futile attempts to make a living by office and other work.

In the fall of 1870 he became associate editor of the *Railroad Gazette,* which was then published in Chicago. In 1871, the year of the great fire, the publication office was removed to New York and shortly afterward Mr. Forney and S. W. Dunning, who was then editor-in-chief, bought the paper, each owning half. Mr. Forney looked after the engineering and mechanical matters and Mr. Dunning had charge of the transportation and traffic department and general railroad news.

In 1870 Robert Fairlie presented a paper before the British Association advocating the adoption of the narrow gauge for railroads, in place of the wider gauges then in use. It was contended that the use of the three-foot gauge would reduce the expense of building and equipping a road in a ratio of about 3 ft. to 4 ft. 9½ in. Difficulty was being met, especially in the western portions of this country, in building and operating new roads and this promise of reduced costs immediately attracted widespread attention. Mr. Forney, single-handed and alone at the beginning, opposed the adoption of the narrow gauge, although practically all of the technical papers, including such authorities as *The Engineer* of London and *London Engineering,* were advocating it. The systematic campaign which he waged and the forcible way in which he presented the facts at his command and combated his opponents, often exposing the fallacy of their arguments by ridicule, undoubtedly kept the craze from reaching serious proportions. Mr. Forney was also very active in advocating the adoption of standard bolts and nuts.

His account of how he came to write the "Locomotive Catechism" is as follows: "In 1873 we obtained a copy of George Kosak's excellent little book on the locomotive, written in German. Mr. Dunning, who reads that language, agreed to translate the book and proposed that I should revise and adapt it to American practice, and that the translation should then be published serially in the *Railroad Gazette* and in book form thereafter. The translation was made and submitted to me for revision and adaptation, according to the original intention. Before that I had planned and had commenced writing an elementary treatise on the locomotive. In revising the first chapter of the translation of Mr. Kosak's book, it was found that it occupied only, to a very limited extent, the ground which in my incomplete plan I hoped to cover. Therefore the original intention of 'adapting' Mr. Kosak's work was abandoned, and the whole book was rewritten and published in book form thereafter. In writing it, the aim was to explain the principles, construction and operation of locomotives in the simplest and clearest language possible, so as to be easily comprehended by engineers, mechanics, firemen and apprentices who have had few educational advantages. The only mathematics employed, excepting simple arithmetic, was one algebraic formula, and that might have been omitted. The book seemed to supply a need, and at once had a large sale, which has continued ever since. It was rewritten and enlarged in 1889, and the demand for the revised edition still continues."

In the early seventies, before any system of transit more rapid than horse cars existed in New York, the traffic was seriously obstructed by each severe snow storm during the winter. A great many projects were proposed for alleviating this condition and in 1874 the American Society of Civil Engineers, of which Mr. Forney was a member, appointed a committee to investigate conditions and recommend plans for the best means of rapid transit for passenger service and the best and cheapest methods of delivering, storing and distributing goods and freight in and about the city of New York. Mr. Forney and Mr. Octave Chanute, then chief engineer of the Erie Railroad, had most of the work in preparing the report, which without doubt had much influence in bringing about the enactment of a rapid transit act under which the existing elevated roads were built. The problem of motive power for the elevated roads was successfully solved by the use of the Forney type locomotive and these were used exclusively on New York and Chicago elevated roads until superseded by electric power.

In 1872 Mr. Forney became an associate member of the American Railway Master Mechanics' Association and in 1873 of the Master Car Builders' Association. At that time no direct relationship existed between the railroads and the Master Car Builders' Association and it soon became evident to Mr. Forney that the field of usefulness of the Association could be greatly extended by giving the railroad companies a representation in its deliberations. After much discussion and many reports the Association was reorganized and placed on its present basis. The effect of this change soon became apparent and the influence of the Association has steadily increased since that time. After the reorganization Mr. Forney was appointed secretary of the Association, which position he held until 1899, when because of the pressure of other duties he asked to be relieved.

The following extracts are taken from a report of a committee (1889), consisting of Messrs. E. B. Wall, Godfrey W. Rhodes and J. S. Lentz, "appointed to express the appreciation of the Association for the services and character of M. N. Forney, ex-secretary":

"The Master Car Builders' Association is under greater obligations to Mr. M. N. Forney than to any other one man for its elevation to the position of confidence and usefulness it now holds in the railway world."

"Mr. Forney, as an associate member contributed much useful information to the Association, but the great work with which he was most prominently identified was the reorganization of the Association in 1882. By this reorganization the railways became directly and officially represented in the work of the Association, and its sphere of usefulness was greatly enlarged."

"It was most fortunate to the railway companies that there was at that time a man possessing their confidence, by reason of his technical attainments and solidity of character, who could disinterestedly set about this work."

"After the reorganization was effected, the Association was fortunate in retaining the services of Mr. Forney as secretary. His work since then has been characterized by patient enthusiasm, painstaking care in the discharge of his duties, and an insistence for technical correctness which has contributed very greatly to the value of the recommendations of the Association."

In 1871 a committee of the Master Car Builders' Association was appointed to prepare a "dictionary of terms used in car building." This committee was too large and it finally narrowed down to three members, Mr. Forney doing the writing and Leander Garey and Calvin Smith acting as consulting members of the committee. After several years of hard work the "dictionary" was completed and in 1879 it was published by the *Railroad Gazette.*

Messrs. Forney and Dunning continued to publish the *Railroad Gazette* until the end of 1883 when Mr. Forney sold his interest to W. H. Boardman, who had been business manager of the paper for several years. For three years following this he was not engaged in any regular business, but this soon became wearisome and in the latter part of 1886 he bought the *American Railroad Journal* and *Van Nostrand's Engineering Magazine,* and on the first of January, 1887, consolidated these two publications under the name of *The Railroad and Engineering Journal.* This he published and edited until the end of 1895, changing the name, however, in 1893 to the *American Engineer and Railroad Journal.* On January 1, 1896, he sold his interest in it to R. M. Van Arsdale, the proprietor of the *National Car and Locomotive Builder,* who then consolidated the two publications. Part of the agreement in making the sale was that Mr. Forney should edit the new paper for one year; in this he was assisted by W. H. Marshall.

Since that time he has not been engaged in any regular business, but has been occupied in a number of different ways and in

a variety of matters. Among other things he has given a great deal of attention to reforming the practice of high-checking horses. He has also worked on the design of a balanced locomotive, his intention being to do away with the crank axle.

He remained a bachelor until 72 years of age and on June 25 of last year was married to Mrs. Annie Virginia Spear of Baltimore, a friend of his youth.

Invention always had a great fascination for Mr. Forney, and in all he was allowed over 30 patents, most of them in connection with improvements to locomotives and cars. While the mechanical development of these various devices proved intensely interesting, the effort required to introduce them was always more or less obnoxious to him and he did not receive any financial returns except from two—the improved tank or Forney type locomotive and a car seat.

He gave much time to the improvement of social and political affairs and was a member of the American Free Trade League and American Peace Society of Boston, the Citizen's Union and Anti-Imperialist League of New York. He was also a member of the Union League, the Century, the Engineers' and the New York Railroad Clubs. In 1898 he was elected an honorary member of the American Railway Master Mechanics' Association and in 1890 was elected a life member of the Master Car Builders' Association. He was one of the organizers of the American Society of Mechanical Engineers; also of the New York Railroad Club.

In addition to the Master Car Builders' "Dictionary" and his "Locomotive Catechism" he wrote two or three books on political subjects, which, however, as far as he could see, did not accomplish any apparent results.

BUILDING WOODEN FREIGHT CARS

CANADIAN PACIFIC RAILWAY*

Synopsis.

Introductory.

The Canadian Pacific Railway has at Angus, Montreal, one of the largest and best operated wooden car building plants, under railroad management, on this continent. Some idea of its importance may be gained from the fact that all of the new freight and passenger cars for the system are built at these shops. During the year ending June 30, 1907, the freight car department built the following equipment:

4,644 Box cars, 30 ton.
12 Refrigerator cars, 38 ft.
260 Stock cars, 30 ton, 36 ft.
361 Flat cars, 40 ton, 41 ft.
782 Flat cars, 30 ton, 36 ft.
254 Hart ballast cars, 40 ton, 34 ft.
4 Derrick cars, eight wheel.
9 Flangers.
9 Snow plows.
38 Refrigerator cars for passenger service.

During the same time the passenger car department built 248 cars as follows:

22 Sleeping cars.
19 Dining cars.
77 First class coaches.
21 Suburban coaches.
24 Colonist cars.
3 Observation cars.
11 Smoking and baggage cars.
19 Baggage cars.
8 Baggage and express cars.
16 Mail and express cars.
1 Official car.
2 Baggage commissariat cars.
25 Box baggage cars (box cars with passenger and baggage car equipment).

The freight car repair yard at Montreal is not included in the Angus shop plant, but is located at Hochelaga, a mile or two distant. Up to the first of last July most of the passenger car repairs were made at the old shops at Hochelaga, only a comparatively few of the heavier repairs being done at the Angus shops. During the year ending June 30, 1907, 41 extra heavy repairs were made at Angus and 16 sleeping and 8 official cars were given general repairs. The capacity of the passenger car shops at Angus is being practically doubled by the addition of new buildings and equipment, and it is the intention to repair, as well as build, all of the passenger cars there from this time on. In addition to the new cars which are built, manufactured material for repairs is supplied to the entire system. The company finds it greatly to its advantage to manufacture and build its equipment both because of the large amount of this work, due to the size of the system and the rapidity with which it is growing, and because of the heavy duty on imported material.

The arrangement, construction and equipment of the locomotive and car shops were described at length in this journal in 1905 and the purpose of the present article will be to consider the organization and operation of that portion of the car department devoted to freight cars, as due to the present extension of the passenger car department the conditions for making a similar study are not as favorable as they will be at a later period. To present this study in a comprehensive manner, and such as will appeal to the reader, the building of a standard box car will be described, starting with the ordering of the raw material and finishing with the car as it is turned over to the operating department. The idea will be not so much to consider each process in detail as to trace the material from start to finish, directing special attention to those features of manufacture or organization which possess special merit.

During part of August and September, 28 of these 30-ton, standard box cars were built for each day of ten hours. This is at the rate of one every 22 minutes, or less, of working time. The car bodies were erected at the rate of one car for every 8⅓ men, every ten hours. It may readily be seen that to accomplish this would require not only good facilities but a splendid organization. On several days a larger number of cars was turned out, the record being 40 for one day. While the detail description of the building of these cars will possibly not appeal to all of our readers, there are certain underlying features or principles which are applicable to all classes of work and are worthy of careful study. Especially noticeable is the co-operation between the vari-

* The Canadian Pacific Railway is a wonderful property. It owns a line extending from the Atlantic to the Pacific oceans with thousands of miles of branch lines. The last annual report gives the grand total mileage as 10,239 miles, including 823 miles under construction. It owns a line of steamers from Quebec to Liverpool and another from Vancouver to Yokohama; also lake and coast steamships. It owns the Dominion Express Company which operates the express business over its lines; also the telegraph lines which serve its territory, and its own parlor and sleeping cars. It owns a controlling interest in two United States lines—the Duluth, South Shore & Atlantic (600 miles) and the Minneapolis, St. Paul & Sault Ste. Marie (2.282 miles). It owns 14,800,000 acres of unoccupied land.

In a letter read before the Canadian parliament last spring Sir Thomas Shaughnessy, president of the company, showed that during the previous 5 years $28,000,000 had been spent on equipment, $44,000,000 on improvements to the existing lines, shops and roundhouses, and $35,000,000 for new lines and new Atlantic steamers. Last year $700,000 was spent on ocean, lake and river steamships, $4,500,000 on construction of new lines, $11,000,000 on additions and improvements, and $13,500,000 on rolling stock, shops and machinery. The gross earnings were $72,200,000, against $61,700,000 in 1906, an increase of 17 per cent. The net earnings were $25,300,000, against $23,000,000 in 1906, an increase of 10 per cent

During the year 5,946,779,961 tons of freight were carried one mile, the average receipts per ton per mile of revenue freight being 0.776 cents. The number of passengers carried (earning revenue) one mile was 1,052,286,316, the average amount received per passenger mile being 1.79 cents.

On June 30, 1907, the rolling stock was as follows: 1,296 locomotives; 1,181 first and second class passenger cars, baggage cars and colonist sleeping cars; 224 first class sleeping, dining and café cars; 51 parlor, official and paymasters' cars; 40,405 freight and cattle cars; 722 conductors' vans; 2,108 board, tool and auxiliary cars and steam shovels.

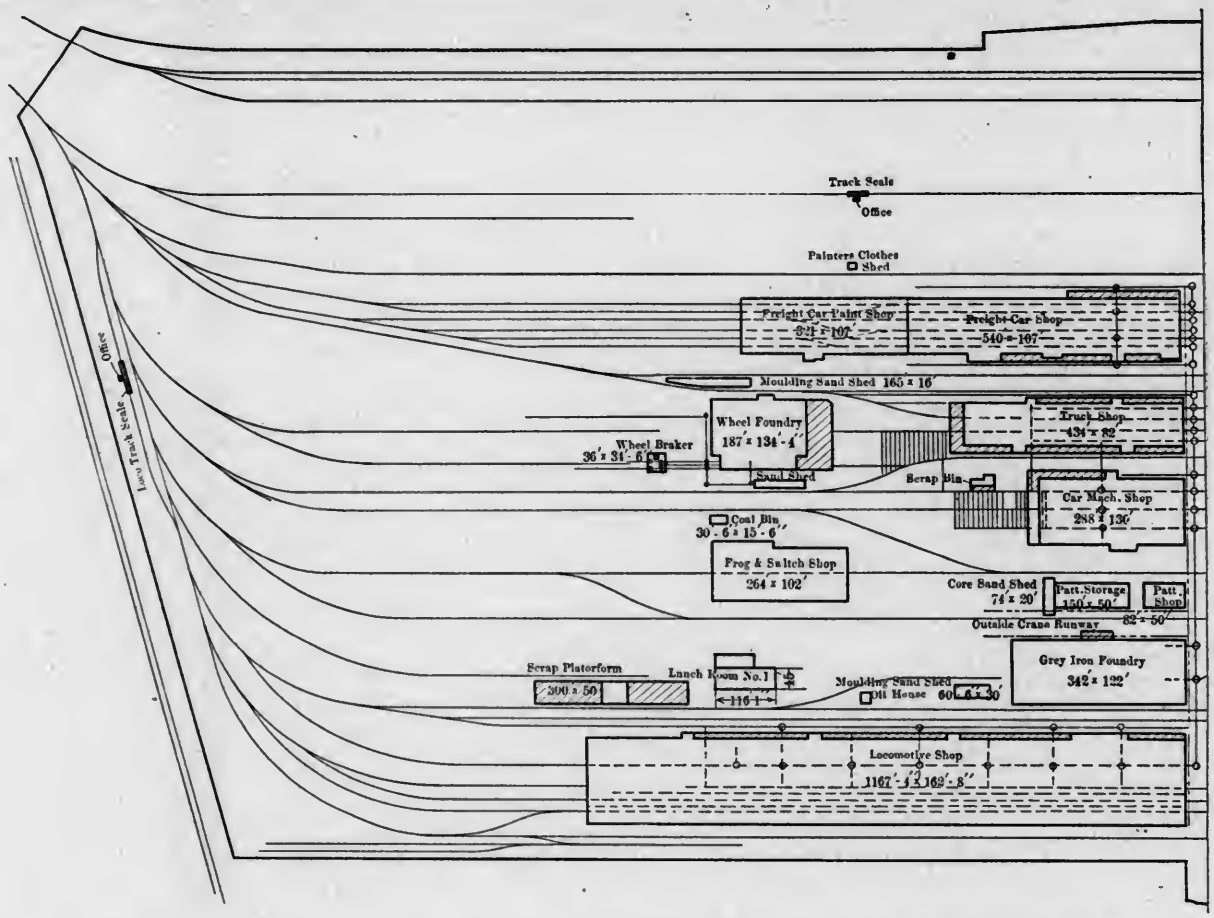


FIG. I.—GENERAL PLAN OF THE ANGUS CAR AND LOCOMOTIVE SHOPS—CANADIAN PACIFIC RAILWAY.

ous departments; the routing of material to keep it moving to its objective point, as directly and with as little re-handling as possible; the simple and orderly arrangement of storing and handling the material; the organization of the erecting gangs in both the truck and car shops, whereby the work is specialized to a high degree and is brought to the men rather than having the men go to the work, thus making each man a part of a large machine and also simplyfying the distribution of material.

As may be seen from a study of the synopsis, the intention is to start from the material yard of the wheel foundry and trace the various operations through the foundry and into the wheel shop until the wheels are mounted on the axle. Leaving them at this point the grey iron foundry and the smith shop will be studied and the material followed from these departments into the car machine shop and thence to the other departments. The next step will be to study the erection of the truck and its movement to the freight car erecting shop. Leaving it here the lumber will be followed from the storage yard through the dry kiln and the planing mill into the erecting shop. The erection of the car body will then be considered in detail, after which it will be followed to the paint shop and thence to the scales, when it will be ready for the operating department.

General Arrangement of the Plant.

A study of the general arrangement of the locomotive and car shops was presented in the December, 1904, issue of this journal, page 451. It will be recalled that this was the largest railroad shop plant ever built and put into service at one time. The arrangement of the various buildings and the facilities provided have proved very satisfactory, but the increasing amount of work, because of the rapid rate at which the system is growing and being extended, has made necessary several additions to the original plant.

The general plan, which is presented herewith, has been revised to date, and by comparing it with the one shown on page 451 of the December, 1904, issue, the additions which have been made will be seen to be as follows: A wing has been added to the southeastern portion of the smith shop and the spring department has been removed to it from the northwestern portion of the building, which is devoted to car department work. When the shops were first installed the new freight cars were painted in the western end of the freight car shop, but it has since been found necessary to provide a separate paint shop by extending the building 321 ft., as shown. The upholstering department has been removed from the second story of the cabinet shop to a new building and a carpet cleaning shed has been erected alongside the upholstering shop. The cabinet shop has been increased in length almost 50 per cent. The transfer table has been extended and a passenger car paint shop has been built on the west side and a new passenger car building shop on the east side. The power house has been extended from 163 to 227 ft. in length and additional power units are being installed.

Organization.

The wheel and grey iron foundries, as may be seen from the accompanying chart, which shows the organization of the freight car department, are under the jurisdiction of the master car builder. The effectiveness of the car department is probably largely due to the broad policy of those in charge, which encourages team work among the foremen and calls forth their best efforts. Each foreman is encouraged to think for himself and plan improvements, and is given all the authority he is individually fitted to assume.

Ordering and Delivery of Material.

When it has been decided by the management to order new equipment the general foreman is instructed to make the proper requisitions. If it is the first order for a piece of equipment the material lists are checked by the drawing room. For succeeding orders it is, of course, not necessary to take this precaution, unless changes have been made in the design. The requisitions, after being O. K.'d by the head of the department, go to the storekeeper. Such material as is to be purchased is then ordered through the purchasing agent.

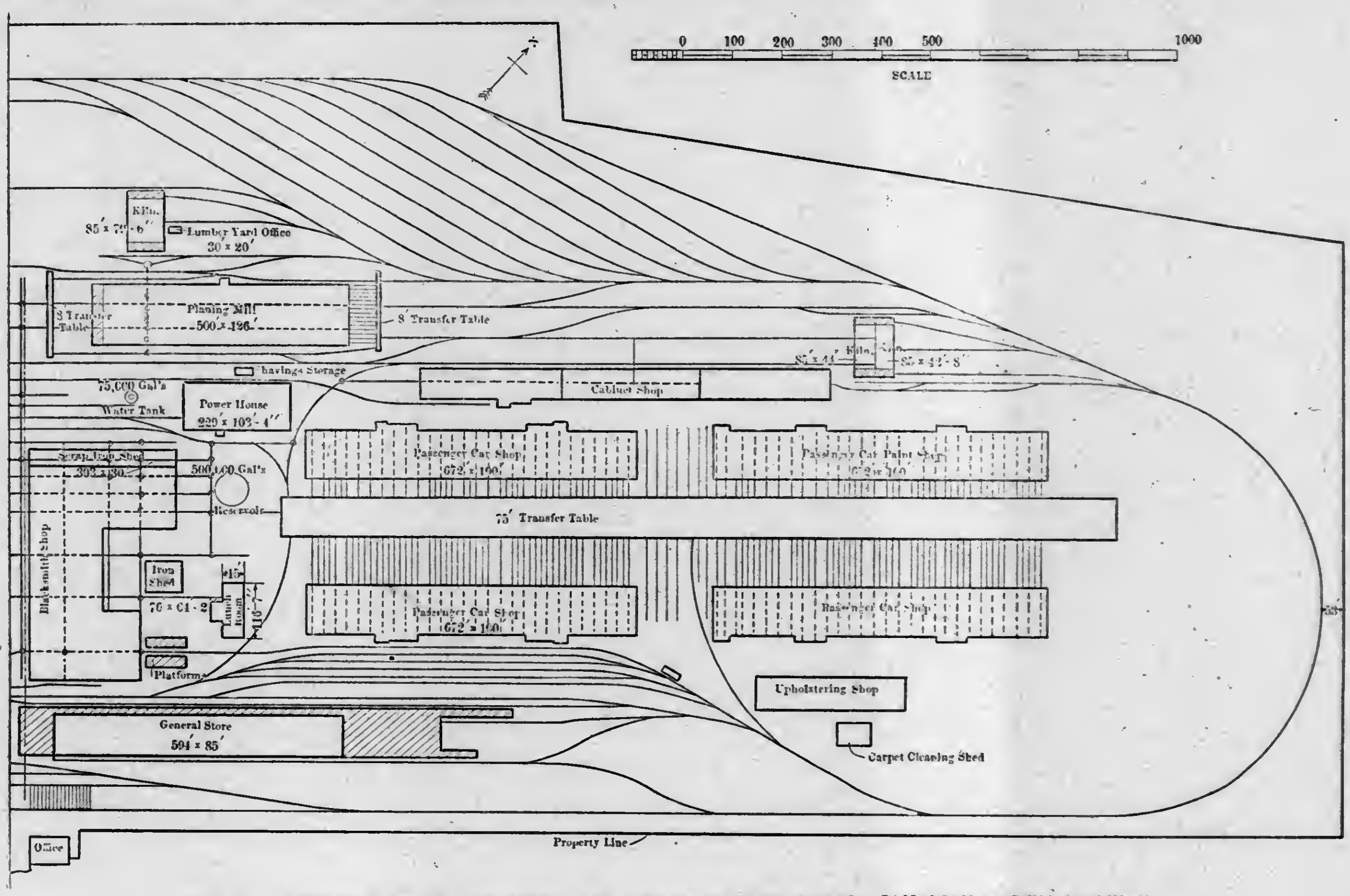


FIG. 1.—GENERAL PLAN OF THE ANGUS CAR AND LOCOMOTIVE SHOPS—CANADIAN PACIFIC RAILWAY.

In a plant with the large output of the Angus shops, it is necessary to keep a close check of all material supplied, and yet this must be done in such a manner as not to interfere with the working of the plant in any way. To do this successfully it is necessary for the storekeeper to have a large force scattered over the entire plant, and to make the wheel and grey iron foundries, as well as some of the other departments, practically sub-storehouses. For instance, all of the material that goes into the cupolas is weighed and checked by a storehouse clerk, and the finished castings are also weighed and distributed under the jurisdiction of storehouse employees. The raw material for the blacksmith shop, although stored just outside of the shop, is in charge of the storekeeper's department and is delivered to the blacksmith department on order from the foreman. The lumber is received by the store department and unloaded, checked, and piled in a yard covering 40 acres. The various foremen order their material from the yard and the checkers see that it is properly delivered. Manufactured material, as will be seen, is stored as near as possible to the place where it is to be used, and is in charge of the storehouse department until it is turned over to the foremen for use.

In addition to such checks as the store department may have upon the material the superintendent of the car department keeps an independent check. When a lot of cars are ordered each item is entered in red ink at the head of a column on a large sheet. When the material is received from the store department the foremen issue what is known as a form "M," as a receipt for it. The blanks for these form "M's" are bound in small books, and each one is carefully numbered and a carbon copy of each order issued remains in the book. Each foreman has two books for each order of cars, and every morning sends the one he is not using to the superintendent's office. A clerk in the office enters the various items of material, which have been drawn, in black ink in the proper columns on the large sheets, and it is possible to see at once just what amount of material is still due on each order. This provides a check against the storekeeper and also against the wasting of material.

- W. E. Fowler, M. C. B.
  - C. F. Rydberg, Supt. Angus Car Shops.
    - C. G. Halley, Genl. Frt. Car Foreman.
      - C. T. Ridalls, Asst. Genl. Frt. Car Foreman.
      - J. McMoon, Foreman Frt. Car Part of Planing Mill.
      - F. Quinn, Asst. Foreman, Car Erecting Shop.
      - H. Beals, " " " " "
      - P. McCabe, Charge Hand, Truck Erecting Gang.
      - T. Kane, " " Painting Gang.
    - H. R. Marengo, Foreman Car Mach. Shop.
      - H. L. Langlars, Asst. Foreman.
      - John Young, Charge Hand, Truck Machine Shop.
      - Lucian Vogin " " Brass Room.
      - Joseph Allard, " " Drillers.
    - H. Nicholl, Foreman Wheel Foundry.
    - A. E. Smith, " Grey Iron Fdy.
    - D. McIntosh, " Cupola and Cylinder Department (Grey Iron Foundry).
    - W. H. Sleep, " Smith Shop.
    - F. D. Zercher, General Foreman, Passenger Car Department.

ORGANIZATION OF THE FREIGHT CAR DEPARTMENT.

Wheel Foundry.*

The wheel foundry is located to the southwest of the truck shop with ample storage space between. Raw material for foundry use is stored southwest of the shed containing the wheel breaker and the scales, which is 36 x 34 ft. 6 in. in size. One of the views, Fig. 2, taken from the top of the breaker house, shows the pig iron piled to the left and the scrap wheels to the right, with the delivery track between. The coke is piled to the right of the scrap wheels and some few cars loaded with it are indistinctly shown in the photo. The pig iron is loaded on small

* For a description of the construction of the building see page 4 of the January, 1905, issue. The equipment and its arrangement are described on page 326 of the September, 1905, issue.

FIG. 3.—INTERIOR OF THE SCALE AND BREAKER HOUSE.

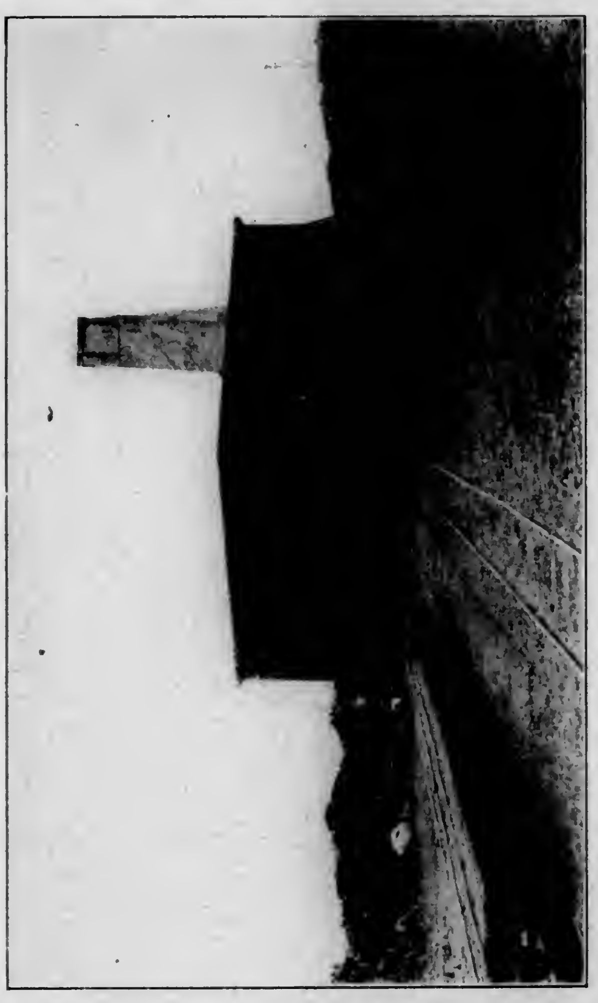


FIG. 4.—SCALE AND BREAKER HOUSE—LOOKING FROM THE END OF THE WHEEL FOUNDRY.

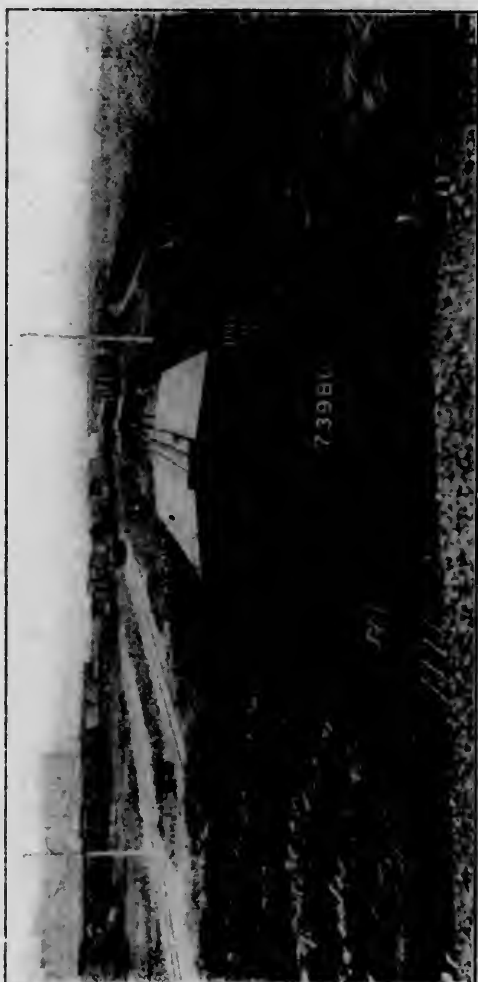


FIG. 2.—VIEW FROM TOP OF SCALE AND BREAKER HOUSE, SHOWING PIG IRON SUPPLIES AT THE LEFT AND SCRAP WHEELS AND COKE AT THE RIGHT.

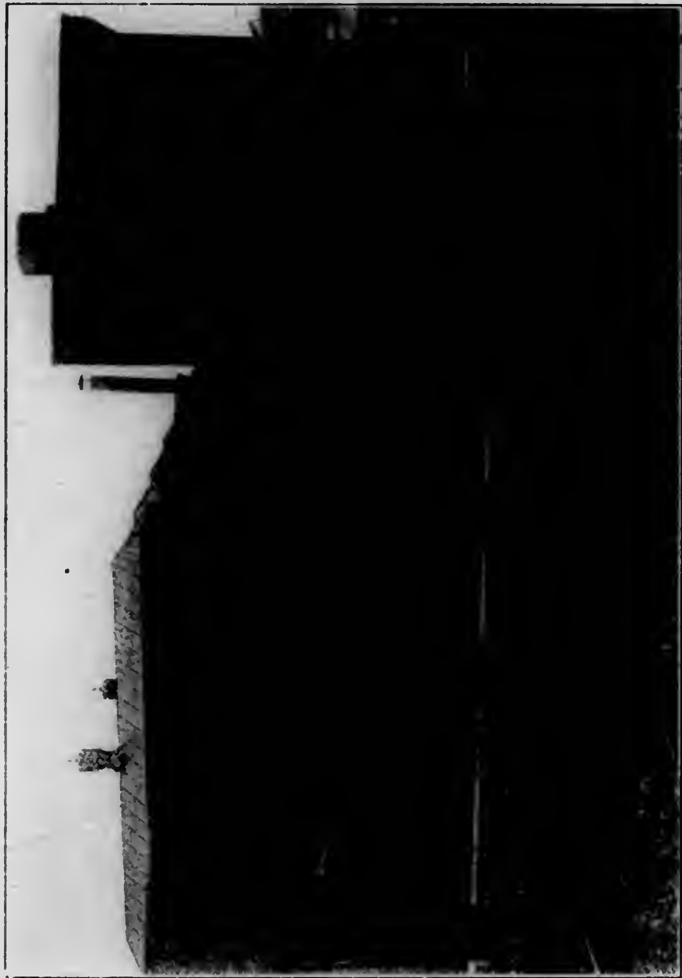


FIG. 5.—PARTIAL VIEW OF THE END OF THE WHEEL FOUNDRY AND THE ENTRANCE TO THE CHARGING ROOM ELEVATORS, LOOKING FROM THE TOP OF THE SCALE AND BREAKER HOUSE.

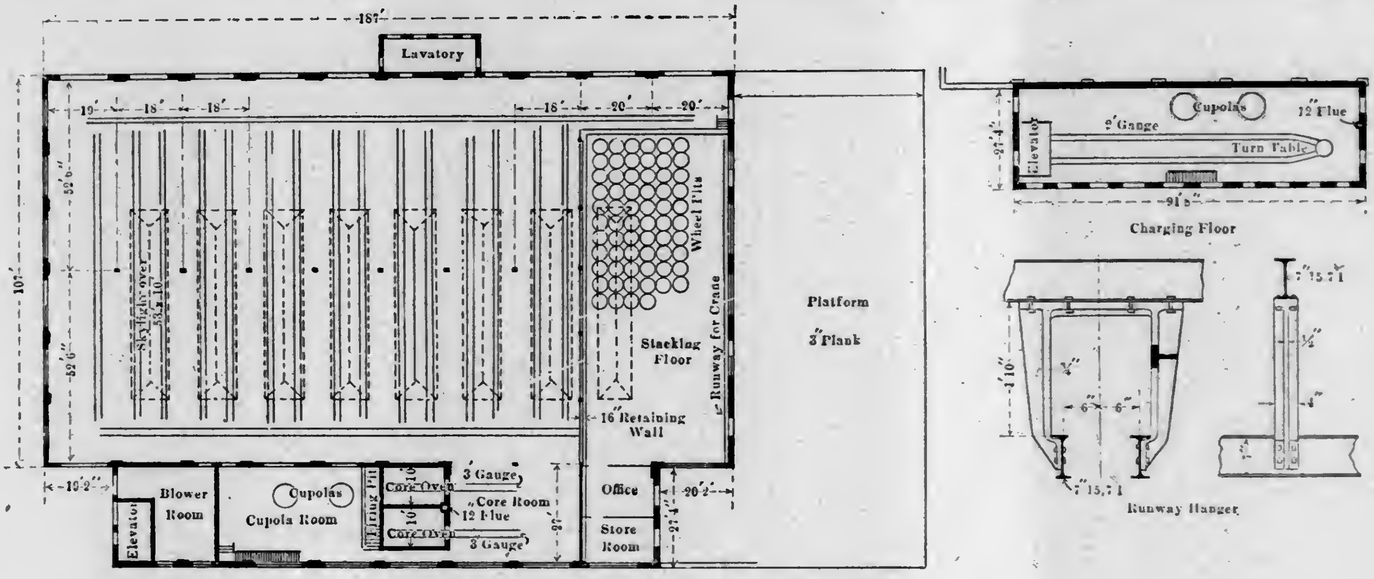


FIG. 6.—FLOOR PLAN OF WHEEL FOUNDRY.

lorry cars, one of which is clearly shown, and pushed into the breaker house, where it is weighed. The scrap wheels are rolled into the other side of the breaker house and broken. A portion of the scale room and the outside of the wheel breaking device are shown in Fig. 3. The breaker weight is hoisted by means of an air cylinder.

Reference to the general plan will show that there are three lorry tracks extending from the scale house to the charging room, the two outside ones being used for the loaded cars and the middle one for returning empties. A front view of the breaker house, with some of the lorry trucks, is shown in Fig. 4. The malleable scrap is stored to the left, only the edge of the pile appearing in this view. The lorry cars have a capacity of two tons each and are lifted to the charging floor by a double elevator operated by a single electric motor, one elevator ascending as the other descends. A partial view of the end of the foundry, showing the entrance to the elevator and fan room, is shown in Fig. 5; also the narrow gauge track alongside the end of the building, which extends to the coke storage and is connected by turntables to the tracks leading to the elevator. Coke is loaded into boxes, without bottoms, on lorry cars. These boxes carry 1,300 lbs. and are easily unloaded in the charging room. The cupolas are charged by hand, four men being required to handle the material from the elevator to the cupola. The arrangement of the narrow gauge tracks leading from the elevator to the cupolas is shown on the plan of the charging floor in Fig. 6.

The entire foundry equipment was furnished by the Whiting Foundry Equipment Company of Harvey, Ill. Two cupolas are provided and are used on alternate days, one being cleaned while the other is in use. These cupolas have 90 in. shells and are lined down to 72 in. at the widest part and 66 in. at the melting zone. They have a capacity of 110 tons or 18½ tons per hour. Between 13 and 14 ounces of blast are used.

The general arrangement of the foundry is shown on the plan, Fig. 6. The molding floor is divided into 15 rows of 21 molds each (daily output 315 wheels), the last mold being between the side wall and the track leading to the annealing pits. Solid cast iron chills are used. Each row is in charge of a molder assisted by a helper; the molding is completed by 10.30 or 11 A. M. when pouring is started. The cupola ladle discharges into five small ladles carried on five trucks, forming a train, and spaced the same distance apart, centre to centre, as are the molding floors. The train is operated by a motor-driven puller machine, controlled by the boy who operates the cupola ladle. Each row, or molding floor, is served by a 1,500-lb. crane. Two cables which control the crane extend across the foundry above the molds. By pulling one cable the crane may be moved to the right or left and by pulling the other the hoist may be raised or lowered, depending on the direction in which the controlling cable is pulled.

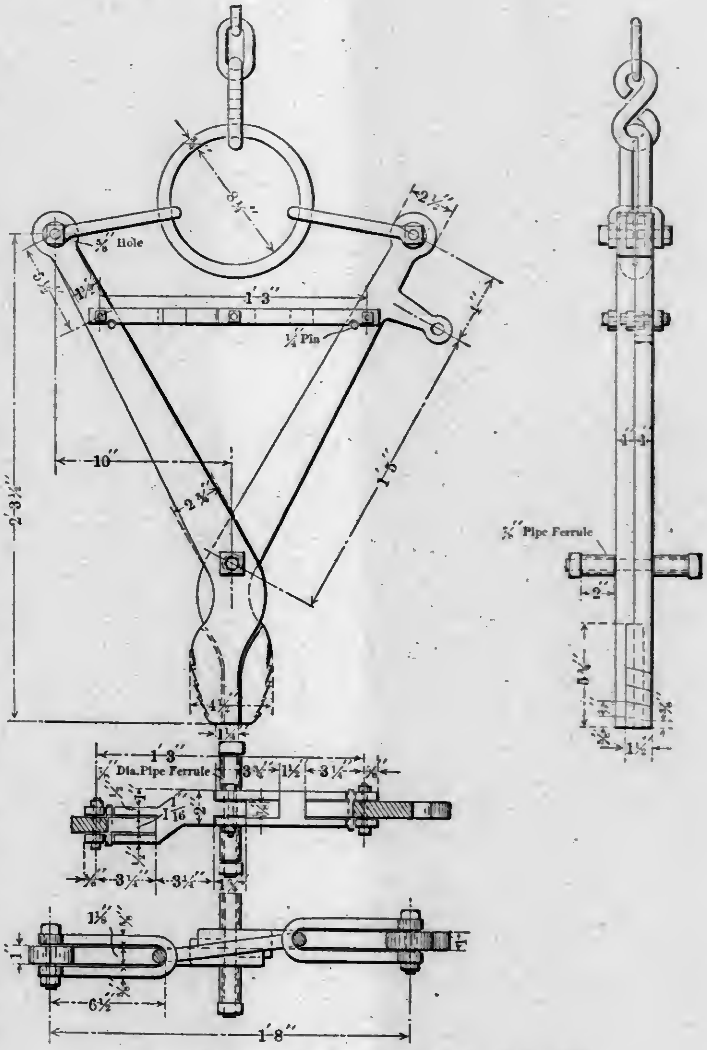


FIG. 9.—WHEEL TONGS USED AT ANNEALING PITS.

Six wheels are poured at one end of the first five rows. The same is done with the next five and then with the last five rows, the men in the rows first poured meanwhile taking out the wheels and sending them to the annealing pits. The wheels are carried to these pits on a train of four trucks which operates on the track on the opposite side of the foundry from the cupola. Nineteen minutes from the time the wheels are poured they are in the annealing pits. In hoisting the wheels from the truck to the annealing pits the tongs shown in Fig. 9 are used. These are quite simple and efficient and were designed by Mr. H. Nicholl,

FIG. 2.—VIEW FROM TOP OF SCALE AND BREAKER HOUSE, SHOWING PIG IRON SUPPLIES AT THE LEFT AND SCRAP WHEELS AND COKE AT THE RIGHT.

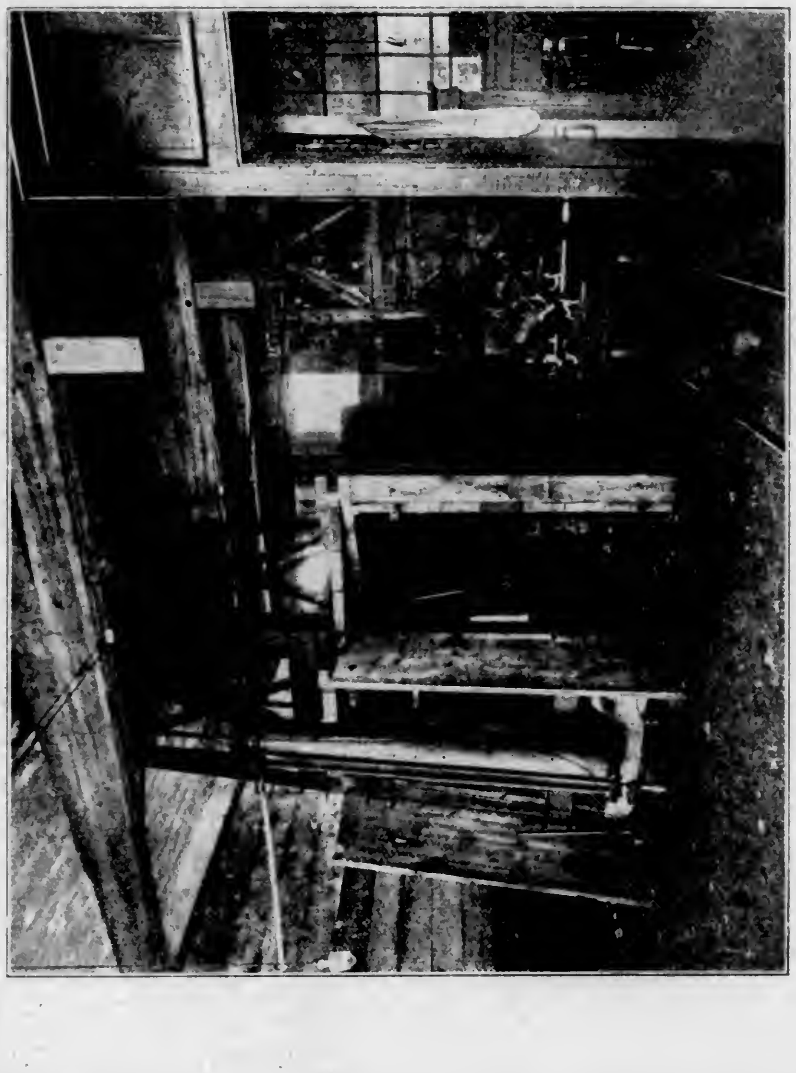


FIG. 3.—INTERIOR OF THE SCALE AND BREAKER HOUSE.

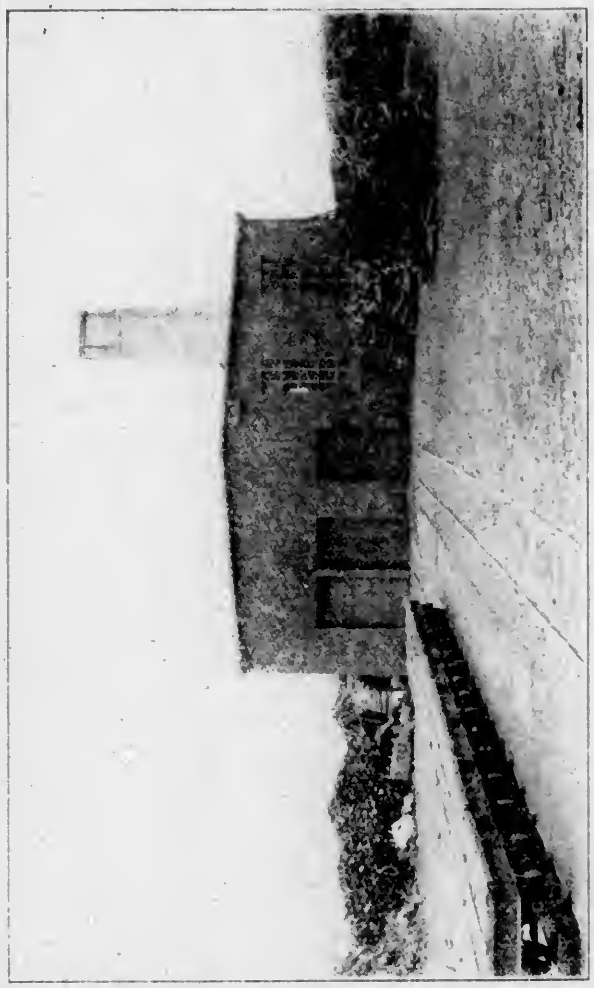


FIG. 4.—SCALE AND BREAKER HOUSE, LOOKING FROM THE END OF THE WHEEL FOUNDRY.

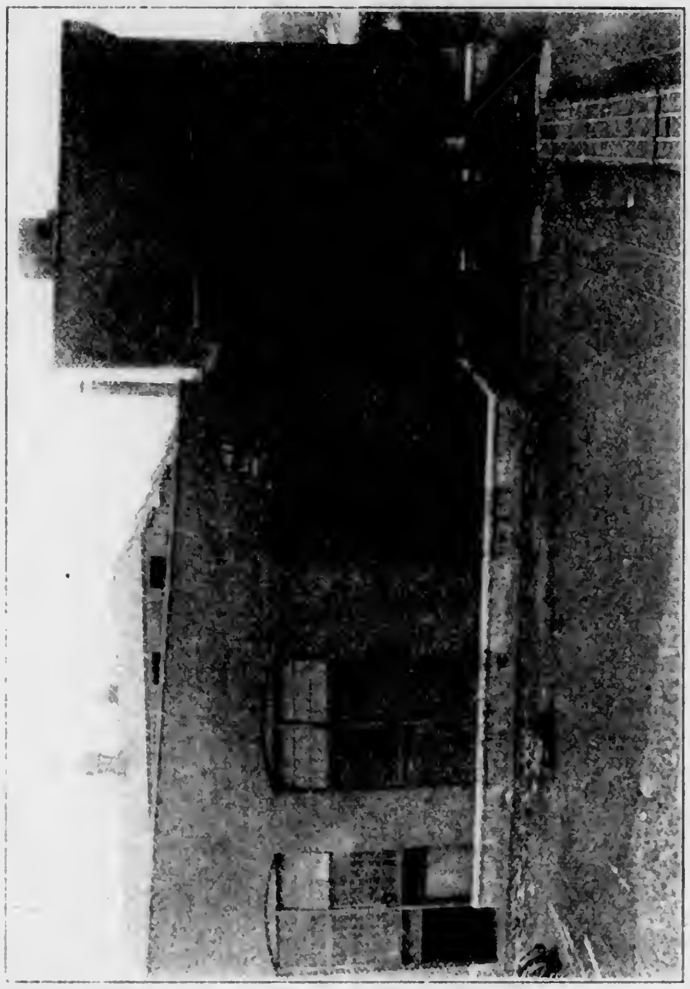


FIG. 5.—PARTIAL VIEW OF THE END OF THE WHEEL FOUNDRY AND THE ENTRANCE TO THE CHARGING ROOM ELEVATORS, LOOKING FROM THE TOP OF THE SCALE AND BREAKER HOUSE.

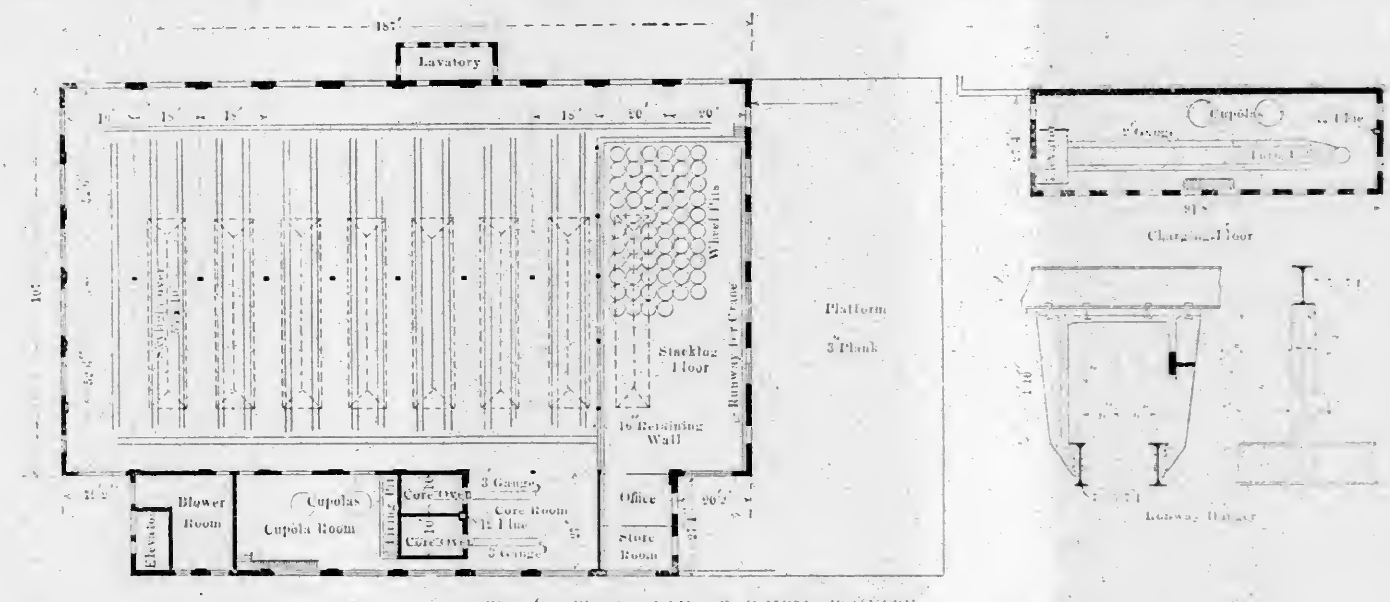


FIG. 6.—FLOOR PLAN OF WHEEL FOUNDRY.

lorry cars, one of which is clearly shown, and pushed into the breaker house, where it is weighed. The scrap wheels are rolled into the other side of the breaker house and broken. A portion of the scale room and the outside of the wheel breaking device are shown in Fig. 3. The breaker weight is hoisted by means of an air cylinder.

Reference to the general plan will show that there are three lorry tracks extending from the scale house to the charging room, the two outside ones being used for the loaded cars and the middle one for returning empties. A front view of the breaker house, with some of the lorry trucks, is shown in Fig. 4. The malleable scrap is stored to the left, only the edge of the pile appearing in this view. The lorry cars have a capacity of two tons each and are lifted to the charging floor by a double elevator operated by a single electric motor, one elevator ascending as the other descends. A partial view of the end of the foundry, showing the entrance to the elevator and fan room, is shown in Fig. 5; also the narrow gauge track alongside the end of the building, which extends to the coke storage and is connected by turntables to the tracks leading to the elevator. Coke is loaded into boxes, without bottoms, on lorry cars. These boxes carry 1,300 lbs. and are easily unloaded in the charging room. The cupolas are charged by hand, four men being required to handle the material from the elevator to the cupola. The arrangement of the narrow gauge tracks leading from the elevator to the cupolas is shown on the plan of the charging floor in Fig. 6.

The entire foundry equipment was furnished by the Whiting Foundry Equipment Company of Harvey, Ill. Two cupolas are provided and are used on alternate days, one being cleaned while the other is in use. These cupolas have 90 in. shells and are lined down to 72 in. at the widest part and 66 in. at the melting zone. They have a capacity of 110 tons or 18½ tons per hour. Between 13 and 14 ounces of blast are used.

The general arrangement of the foundry is shown on the plan, Fig. 6. The molding floor is divided into 15 rows of 21 molds each (daily output 315 wheels), the last mold being between the side wall and the track leading to the annealing pits. Solid cast iron chills are used. Each row is in charge of a molder assisted by a helper; the molding is completed by 10.30 or 11 A. M. when pouring is started. The cupola ladle discharges into five small ladles carried on five trucks, forming a train, and spaced the same distance apart, centre to centre, as are the molding floors. The train is operated by a motor-driven puller machine, controlled by the boy who operates the cupola ladle. Each row, or molding floor, is served by a 1,500-lb. crane. Two cables which control the crane extend across the foundry above the molds. By pulling one cable the crane may be moved to the right or left and by pulling the other the hoist may be raised or lowered, depending on the direction in which the controlling cable is pulled.

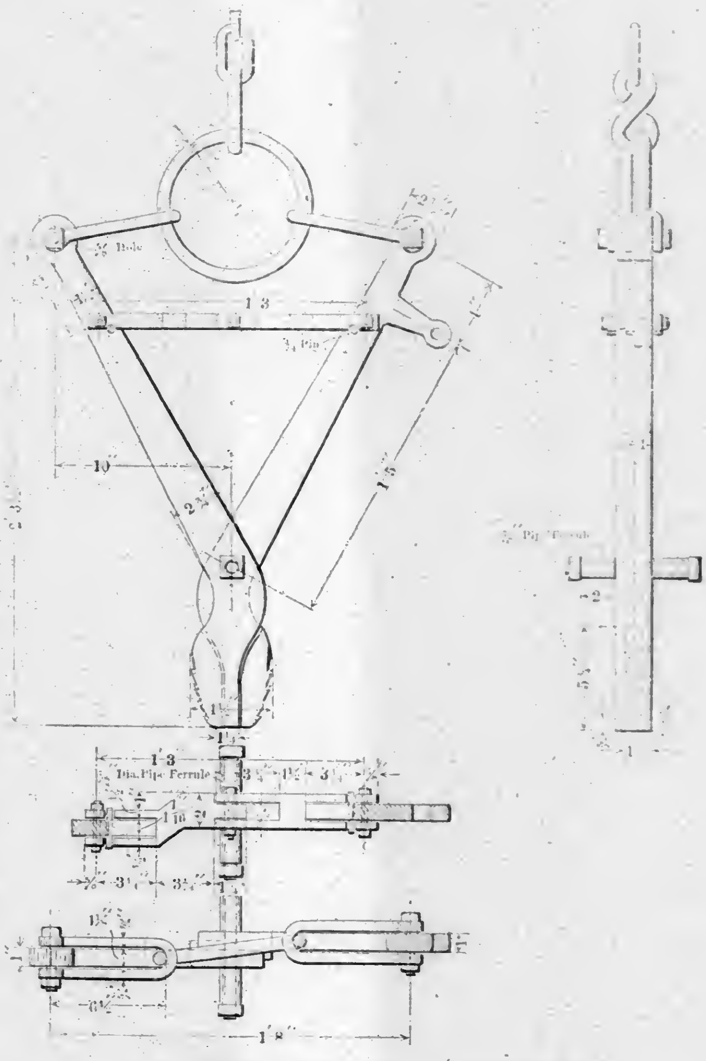


FIG. 9.—WHEEL TONGS USED AT ANNEALING PITS.

Six wheels are poured at one end of the first five rows. The same is done with the next five and then with the last five rows, the men in the rows first poured meanwhile taking out the wheels and sending them to the annealing pits. The wheels are carried to these pits on a train of four trucks which operates on the track on the opposite side of the foundry from the cupola. Nineteen minutes from the time the wheels are poured they are in the annealing pits. In hoisting the wheels from the truck to the annealing pits the tongs shown in Fig. 9 are used. These are quite simple and efficient and were designed by Mr. H. Nicholl,

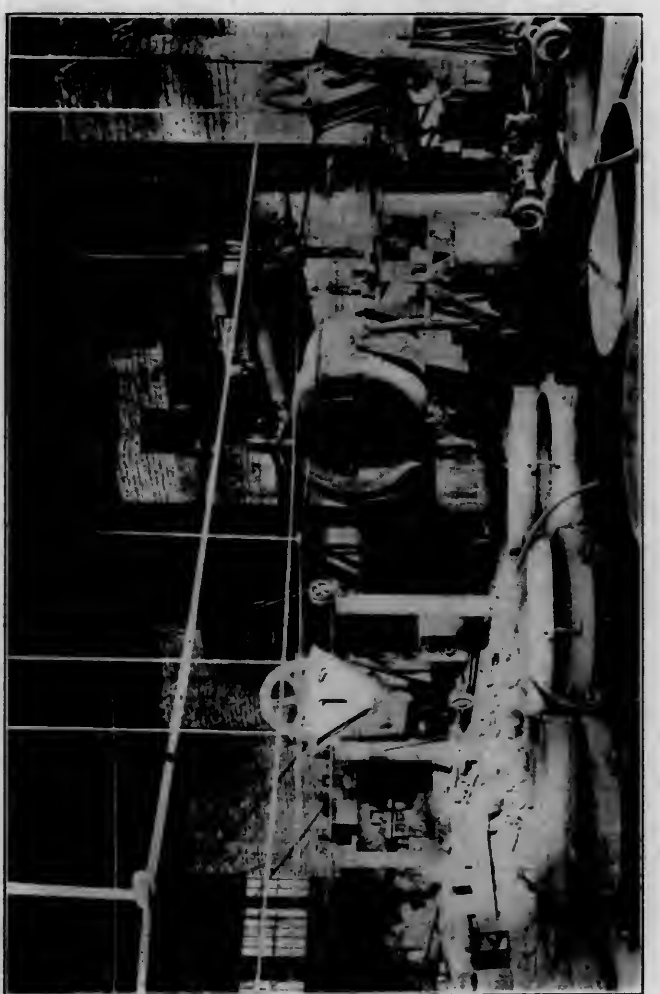


FIG. 7.—LOOKING TOWARD THE CUPOLA ROOM IN THE WHEEL FOUNDRY AND SHOWING SMALL LADLES ON TRUCKS.

FIG. 10.—WHEEL FOUNDRY AND SHIPPING PLATFORM, LOOKING FROM THE TRUCK SHOP.

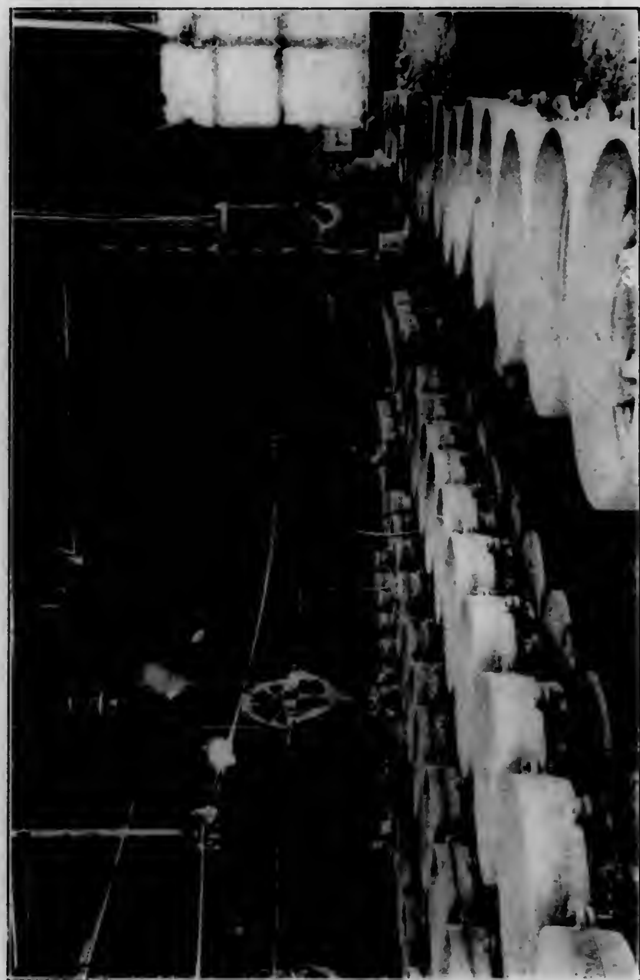


FIG. 8.—ARRANGEMENT OF MOULDING FLOORS IN THE WHEEL FOUNDRY, SHOWING THE CABLES WHICH CONTROL THE TRAVELING HOISTS ABOVE EACH FLOOR.

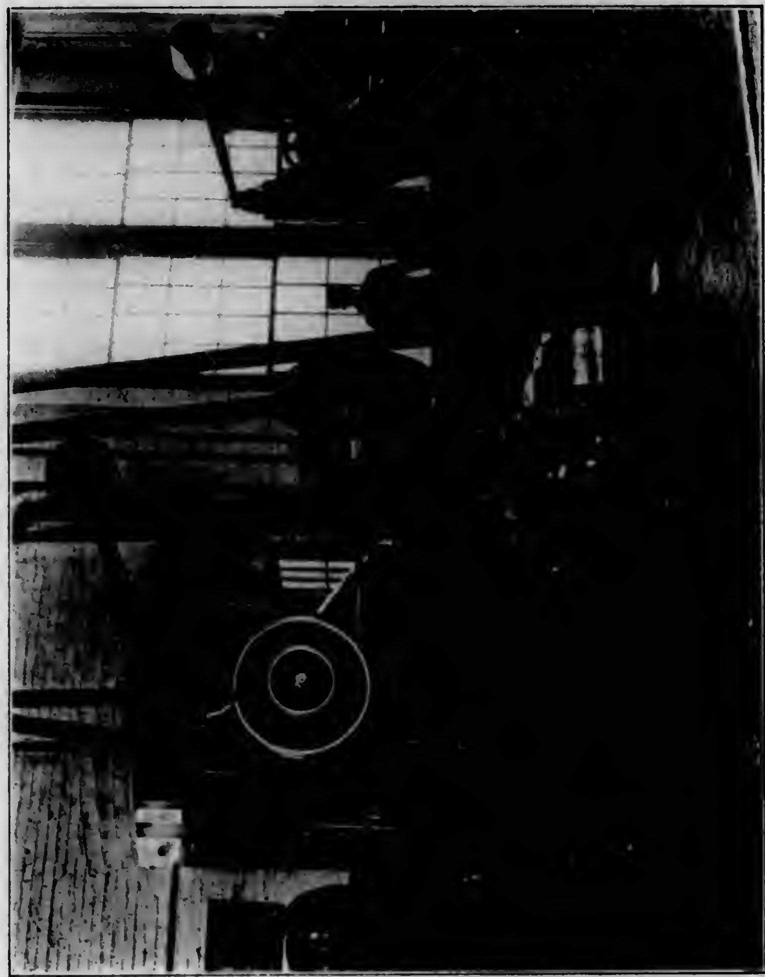
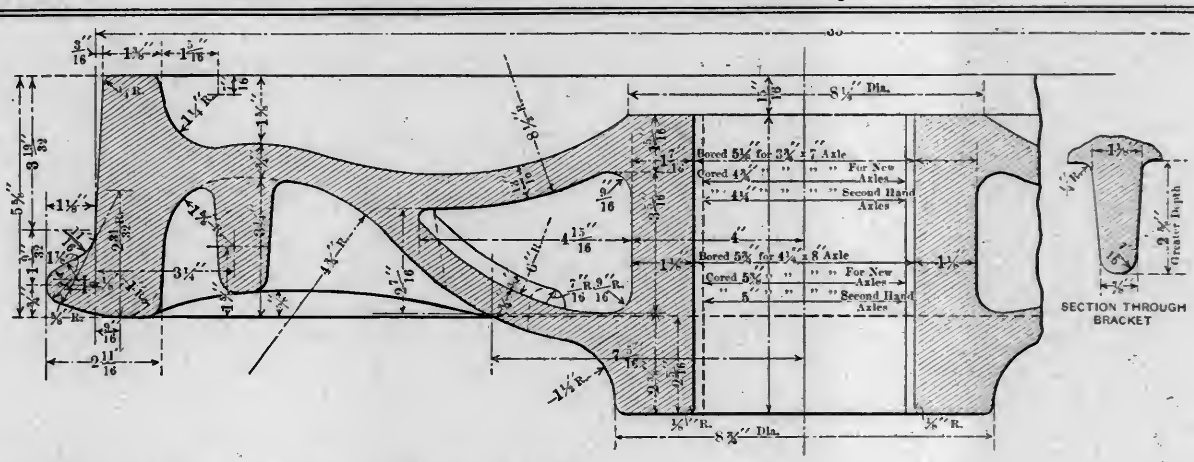


FIG. 13.—NILES WHEEL BORING MILL. THE WHEEL IN THE FOREGROUND LEANING AGAINST A WOODEN POST WILL FOLLOW THE ONE ON THE MACHINE.



the foreman. When the tongs are lowered into the hubs the centre of the hinged cross piece is forced upward and the tongs grip the wheel securely. When it is desired to remove the wheels from the pits the tongs are lowered, and when the end is in the hub the cross piece is forced upward by a chain. As soon as the wheel is lowered to the ground the arms tend to spread apart at the top, due to gravity, and the cross piece falls into place and prevents the tongs from gripping the wheel again.

A 3,000-lb. Whiting crane, with two hoists, thus handling two wheels at a time, extends over the annealing pits. As shown on the plan view, there are four rows of 11 pits and two of 10 each. Each pit holds 19 or 20 wheels. The wheels remain in the pits four days and are then placed on the floor, where they are stacked with a Whiting piling truck. After they have cooled sufficiently they are cleaned and taped. The finished wheels are then either rolled out on the platform, shown in Fig. 10, and loaded directly from this on a car for shipment to other points, or they are rolled to the truck shop to be bored and mounted, or are stored just outside of that shop.

A thermal test is made each day. Barber rollers for the freight car trucks are made of the wheel mixture and are cast in cast-iron molds. The core room and core ovens are located between the office and cupola room.

Design of the Cast Iron Freight Car Wheel.

Reference to the detail drawing of the Canadian Pacific standard 33-in. cast-iron wheel, Figs. 11 and 20, will show that it varies somewhat from M. C. B. recommended practice. The ribs are arranged with a much greater degree of curvature, thus making the wheel of greater elasticity and reducing trouble due to shrinkage. The flange is also considerably strengthened through the throat because of the additional metal at that point, due to the method of connecting the ribs to it. A somewhat larger core is used in the body of the wheel, the side walls being thinner than those of the M. C. B. wheel. They weigh 650 lbs., or the same as the M. C. B. wheel for 80,000 lb. capacity cars.

Wheel Shop.*

One is impressed with the devices, some of them very simple and yet effective, which have been provided to facilitate the handling of material and the operation of the machine tools, and to conserve the strength of the workman. The workman must not over-exert himself and become exhausted or the output is sure to suffer, and often it is the combination of a number of little things, each apparently unimportant in itself, which uses up his strength and reduces his efficiency and output.

Reference to the plan of that part of the wheel and truck shop, which is devoted to wheels and axles, will show that there is considerable storage room for wheels in the shop itself. The wheels are usually rolled in directly from the foundry; six boring mills are provided. A wooden post is placed near each mill, so that a wheel can be leaned up against it (Fig. 13), while waiting to be placed upon the machine, and can be quickly hoisted into place as soon as the other wheel is removed. The Niles 42-in.

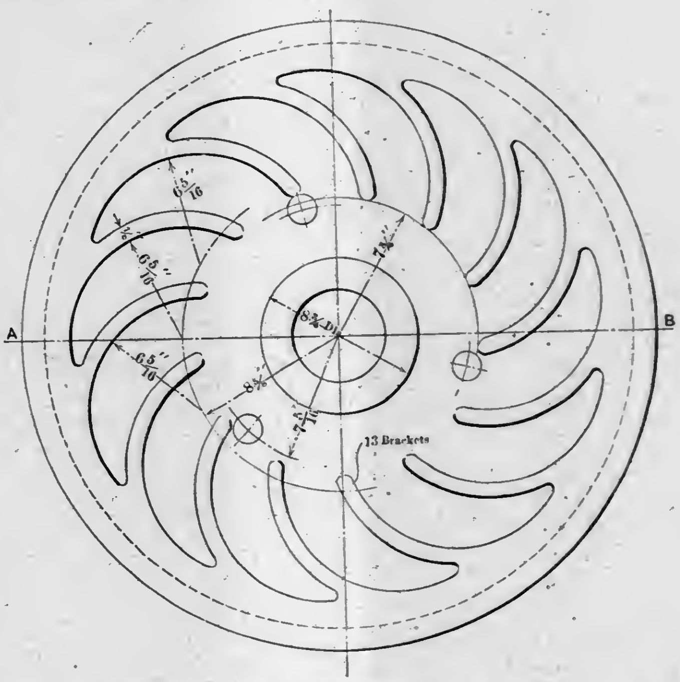


FIG. 11.—STANDARD CAST IRON FREIGHT CAR WHEEL—CANADIAN PACIFIC RAILWAY.

car wheel borer, shown in Fig. 13, has a record for boring 120 car wheels in ten hours. That these machines are operated at a fairly good rate is indicated by the fact that the men warm their tea and coffee, which they usually carry in bottles, in the borings. After the wheels have been bored they are rolled and temporarily stored in the middle of the shop near the wheel presses.

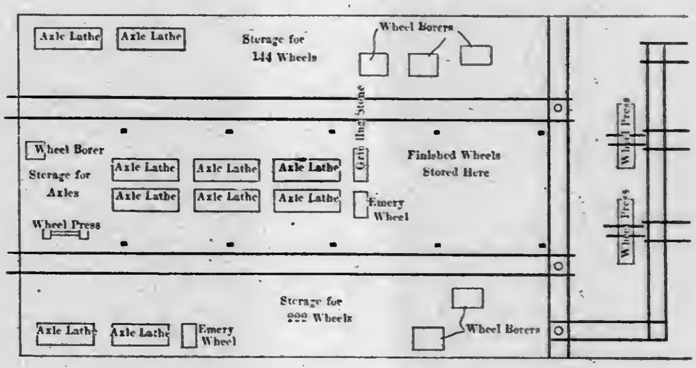


FIG. 12.—PLAN OF TRUCK SHOP.

The axles are stored just outside of the shop and are brought in by the cart, shown in Fig. 14, and also in a different position, in Fig. 15, which shows a group of Niles No. 3 double-axle lathes. One of these lathes has a record of turning twenty-six, 4¼ x 8 in., axles in ten hours. They are served by individual post cranes and the axles are picked up by the device shown hanging

* For a description of the construction of the building and additional details concerning the equipment, see pages 4 of the January and 114 of the April, 1905, issues.

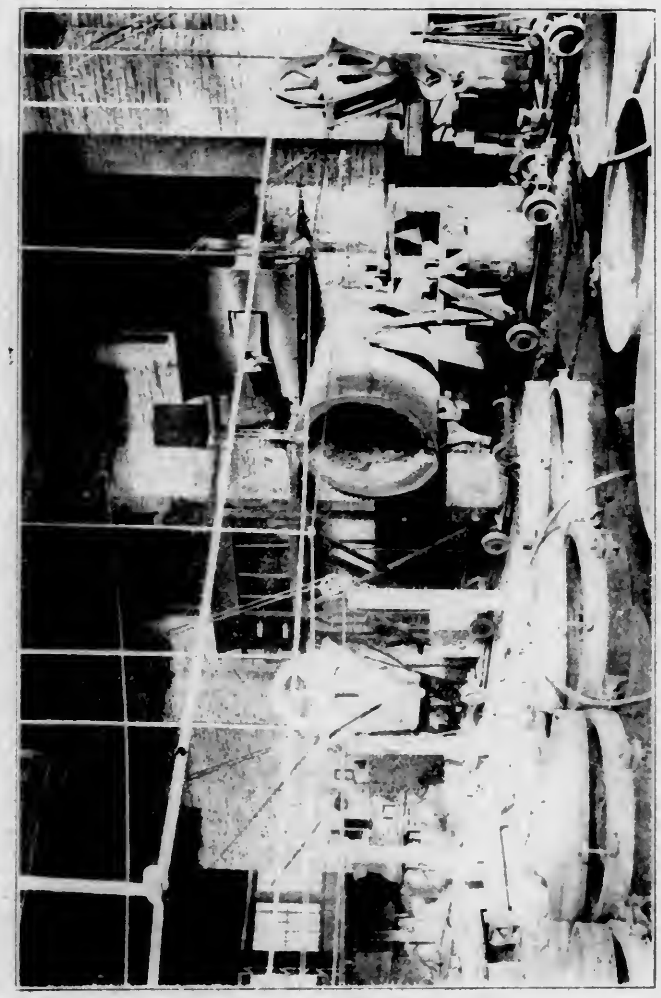


FIG. 7.—LOOKING TOWARD THE CUPOLA ROOM IN THE WHEEL FOUNDRY AND SHOWING SMALL LADLES ON TRUCKS.

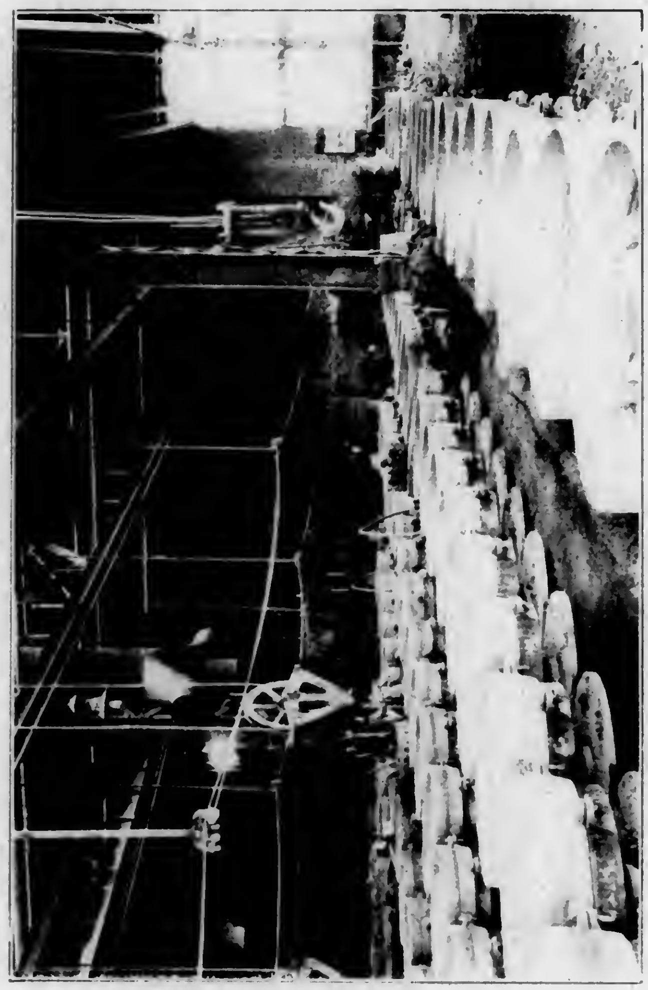


FIG. 8.—ARRANGEMENT OF MOULDING FLOORS IN THE WHEEL FOUNDRY, SHOWING THE CABLES WHICH CONTROL THE TRAVELING HOISTS ABOVE EACH FLOOR.

FIG. 10.—WHEEL FOUNDRY AND SHIPPING PLATFORM, LOOKING FROM THE TRUCK SHOP.

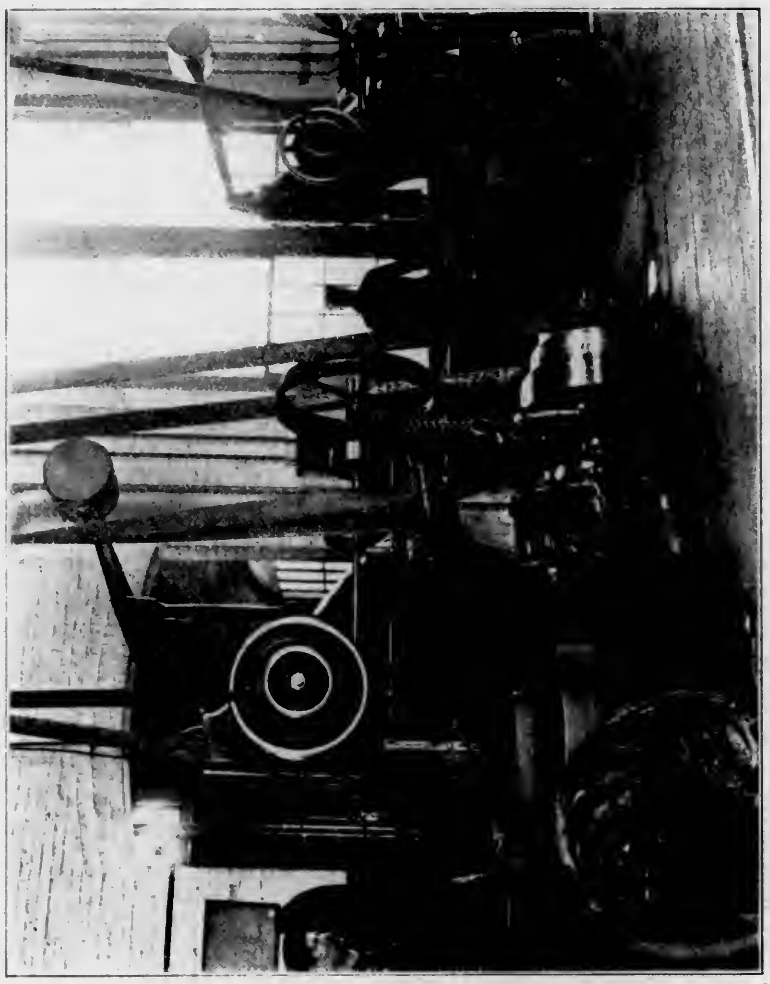
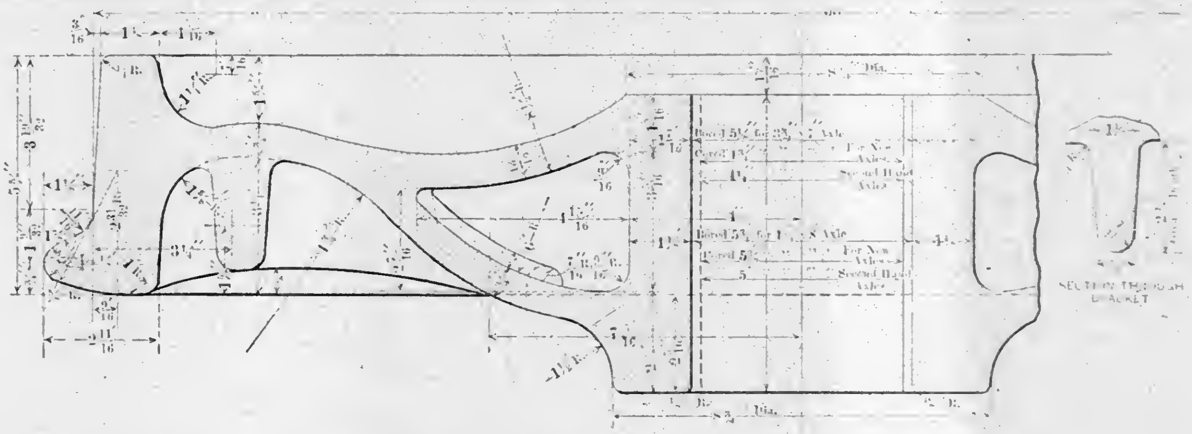


FIG. 13.—NILES WHEEL BORING MILL. THE WHEEL IN THE FOREGROUND LEANING AGAINST A WOODEN POST WILL FOLLOW THE ONE ON THE MACHINE.



the foreman. When the tongs are lowered into the hubs the centre of the hinged cross piece is forced upward and the tongs grip the wheel securely. When it is desired to remove the wheels from the pits the tongs are lowered, and when the end is in the hub the cross piece is forced upward by a chain. As soon as the wheel is lowered to the ground the arms tend to spread apart at the top, due to gravity, and the cross piece falls into place and prevents the tongs from gripping the wheel again.

A 3,000-lb. Whiting crane, with two hoists, thus handling two wheels at a time, extends over the annealing pits. As shown on the plan view, there are four rows of 11 pits and two of 10 each. Each pit holds 10 or 20 wheels. The wheels remain in the pits four days and are then placed on the floor, where they are stacked with a Whiting piling truck. After they have cooled sufficiently they are cleaned and taped. The finished wheels are then either rolled out on the platform, shown in Fig. 10, and loaded directly from this on a car for shipment to other points, or they are rolled to the truck shop to be bored and mounted, or are stored just outside of that shop.

A thermal test is made each day. Barber rollers for the freight car trucks are made of the wheel mixture and are cast in cast-iron molds. The core room and core ovens are located between the office and cupola room.

Design of the Cast Iron Freight Car Wheel.

Reference to the detail drawing of the Canadian Pacific standard 33-in. cast-iron wheel, Figs. 11 and 20, will show that it varies somewhat from M. C. B. recommended practice. The ribs are arranged with a much greater degree of curvature, thus making the wheel of greater elasticity and reducing trouble due to shrinkage. The flange is also considerably strengthened through the throat because of the additional metal at that point, due to the method of connecting the ribs to it. A somewhat larger core is used in the body of the wheel, the side walls being thinner than those of the M. C. B. wheel. They weigh 650 lbs., or the same as the M. C. B. wheel for 80,000 lb. capacity cars.

Wheel Shop.*

One is impressed with the devices, some of them very simple and yet effective, which have been provided to facilitate the handling of material and the operation of the machine tools, and to conserve the strength of the workman. The workman must not over-exert himself and become exhausted or the output is sure to suffer, and often it is the combination of a number of little things, each apparently unimportant in itself, which uses up his strength and reduces his efficiency and output.

Reference to the plan of that part of the wheel and truck shop, which is devoted to wheels and axles, will show that there is considerable storage room for wheels in the shop itself. The wheels are usually rolled in directly from the foundry; six boring mills are provided. A wooden post is placed near each mill, so that a wheel can be leaned up against it (Fig. 13), while waiting to be placed upon the machine, and can be quickly hoisted into place as soon as the other wheel is removed. The Niles 42-in. car wheel borer, shown in Fig. 13, has a record for boring 120 car wheels in ten hours. That these machines are operated at a fairly good rate is indicated by the fact that the men warm their tea and coffee, which they usually carry in bottles, in the borings. After the wheels have been bored they are rolled and temporarily stored in the middle of the shop near the wheel presses.

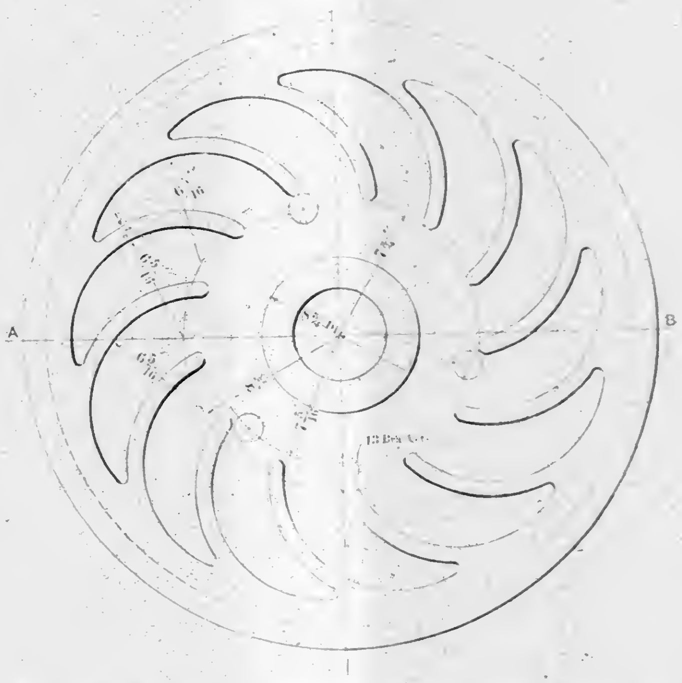


Fig. 11.—Standard Cast Iron Freight Car Wheel.—Canadian Pacific Railway.

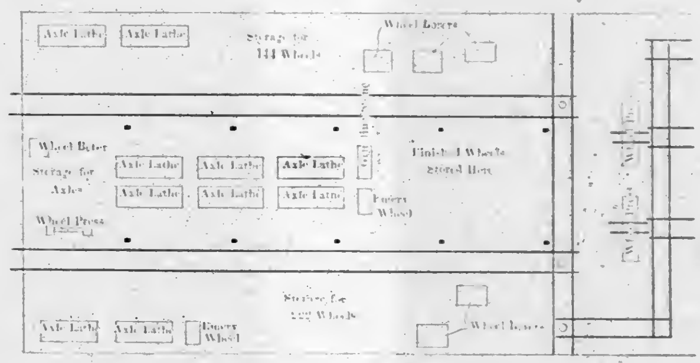


Fig. 12.—Plan of Truck Shop.

The axles are stored just outside of the shop and are brought in by the cart, shown in Fig. 14, and also in a different position, in Fig. 15, which shows a group of Niles No. 3 double-axle lathes. One of these lathes has a record of turning twenty-six, 4¼ x 8 in., axles in ten hours. They are served by individual post cranes and the axles are picked up by the device shown hanging

* For a description of the construction of the building and additional details concerning the equipment, see pages 1 of the January and 111 of the April, 1905, issues.

FIG. 19.—DOUBLE TRUCK FOR MOUNTING WHEELS AND AXLES, IN FOREGROUND. TRUCK FOR TRANSPORTING MOUNTED WHEELS AND AXLES ACROSS THE SHOP, IN THE REAR. IMPROVED SLEEVE ON THE PRESS AT THE RIGHT.

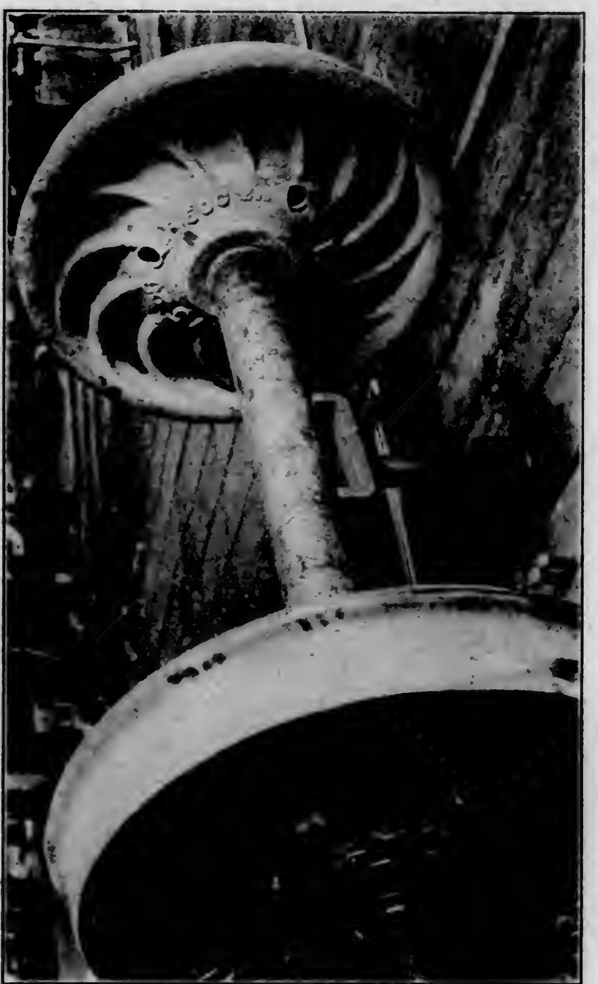


FIG. 20.—DEVICE FOR TURNING MOUNTED WHEELS OR LORRY TRUCKS—USED IN PLACE OF A TURNTABLE.

FIG. 14.—TRUCK FOR HANDLING AXLES.

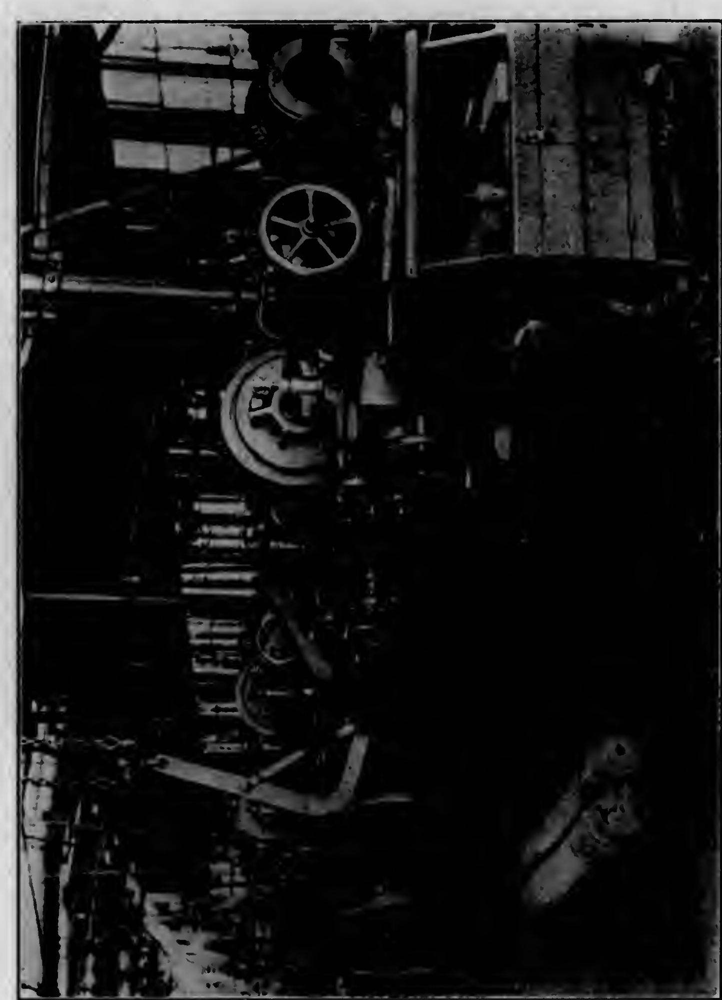


FIG. 15.—A GROUP OF AXLE LATHES WITH AXLE HANDLING TRUCK AT THE LEFT.

FIG. 17.—AIR HOIST IN WHEEL SHOP.

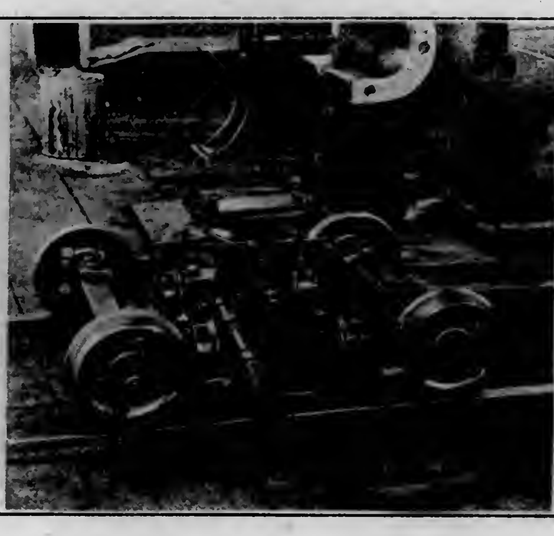


FIG. 18.—DOUBLE TRUCK AT THE WHEEL PRESS.

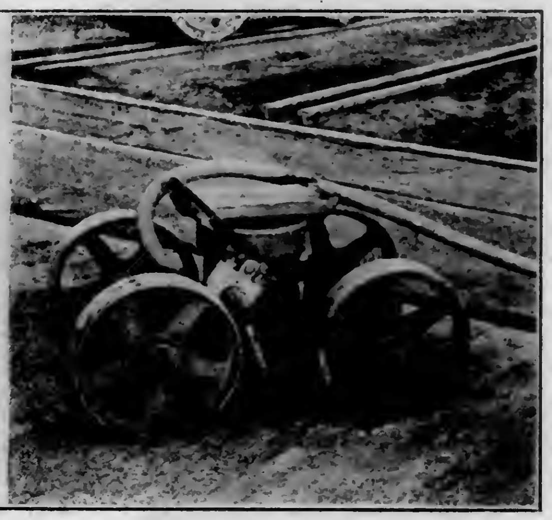


FIG. 21.—PORTABLE PNEUMATIC DEVICE FOR TURNING MOUNTED WHEELS.

from the crane in Fig. 15. To facilitate the picking up of axles with this device they are not laid flat on the floor, but are supported at one end by the plank shown in the foreground. The lathes rest upon concrete foundations (Fig. 16), each foundation being large enough to take two lathes, placed back to back. The cuttings and lubricating compound drop into a pit 14 in. deep, and the compound is drained into a cavity at the centre which contains a sheet iron tank. From this it is pumped back into circulation. The cuttings are cleaned out at regular intervals by laborers, and do not interfere at all with the operator.

These lathes are operated at high speed and to save time, when it is necessary to stop them, a brake, which is operated by the foot, has been placed on the large driving pulley, and quickly brings the machine to a stop. It is important to use cutting tools of a standard size in order that the workman may have as little difficulty as possible in changing from one to another. The shank of the burnishing tool has a pin passing through it which backs up against the tool post, and the only function the set-screw has to perform is to steady the tool. The operator does not have to screw it down nearly as tightly as when it is depended upon to keep the tool from slipping backward.

After the axles have been turned they are stored temporarily near the wheel presses. When ready to have wheels mounted upon them they are picked up by an air hoist, shown in Fig. 17, which operates on the overhead track, and are deposited upon the small truck shown in Figs. 18 and 19. It will be seen that the air hoist has a reservoir attached above it. This is to provide for the traveling back and forth of the hoist and to do away with having an extremely long hose. The reservoir is charged by running it under the charging device, shown in the illustration, it being only necessary to pull the chain, which is shown suspended, thus making an air-tight connection between the reservoir and the charging device and at the same time allowing air to flow into the reservoir. The reservoir has a capacity sufficient for the handling of 3 or 4 axles without re-charging.

The truck upon which the axle is placed preparatory to mounting, Figs. 18 and 19, consists practically of a double truck, the lower portion having a forward and backward movement, and the upper a sidewise motion. As soon as the axle has been placed upon it and the wheel seat has been white leaded, one of the wheels is rolled alongside the truck and the end of the axle is slipped into it by moving the upper part of the axle truck sidewise. The second wheel is then brought forward, and by pressing the lever lightly with the foot air is admitted to the cylinder and the plunger is forced upward raising the end of the axle sufficiently so that the wheel may be slipped over the end. The plunger is then raised to its full height and the truck is moved forward under the wheel press. The wheel press is fitted with a recording pressure gauge as well as with an ordinary gauge. The pressures required for applying wheels for cars and tenders are as follows:

PRESSURES FOR APPLYING WHEELS TO AXLES.

Size of Journals.	Standard Diameter of Wheel Fit.	Cast Iron Wheels.	Steel Tired Wheels.
3¾ x 7	5⅛	30 to 40 tons	45 to 55 tons
4¼ x 8	5¾	35 to 15 "	50 to 60 "
5 x 9	6½	40 to 50 "	60 to 70 "
5½ x 10	7	45 to 55 "	65 to 75 "

An interesting improvement has been made to the wheel press, which adds greatly to its usefulness. Instead of having the sleeve hung from the cross bar it has been fastened on the end of the ram and can be rotated by means of the two handles. While the wheels are being pressed on it is held securely in position by a set screw, but afterward when it is necessary to swing the mounted wheels around in order to place them on the track in the rear of the press, the set screw is loosened and the sleeve revolved 180 degrees, allowing the axle to swing back.

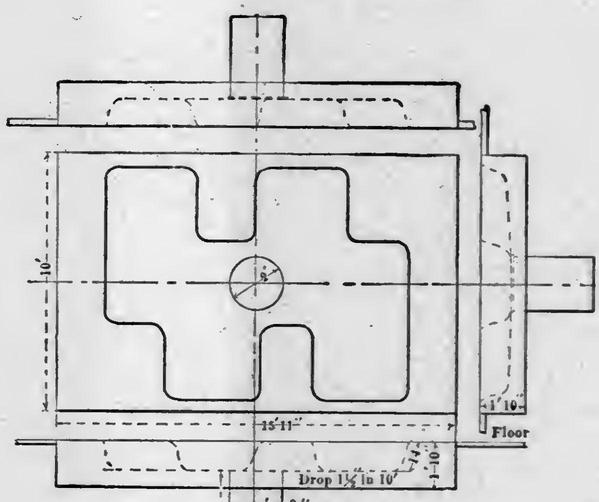


FIG. 16.—CONCRETE FOUNDATIONS FOR AXLE LATHES.

Another characteristic improvement is that the block, which is placed between the end of the axle and the ram, is hung from a hook instead of being left to lie on the floor, and is therefore always at hand when required. The mounted wheels after they have been swung back of the press are run on the wheel truck, shown in Fig. 19, and are moved to one of the tracks running lengthwise through the shop, depending upon whether they are to be used at once in the truck shop or are to be shipped or stored outside of the shop.

Another interesting device, which is not only used extensively in the shops in place of turntables, but is also used in a modified form throughout the yards where it is not advisable to use turntables because heavy cars and locomotives must operate over the

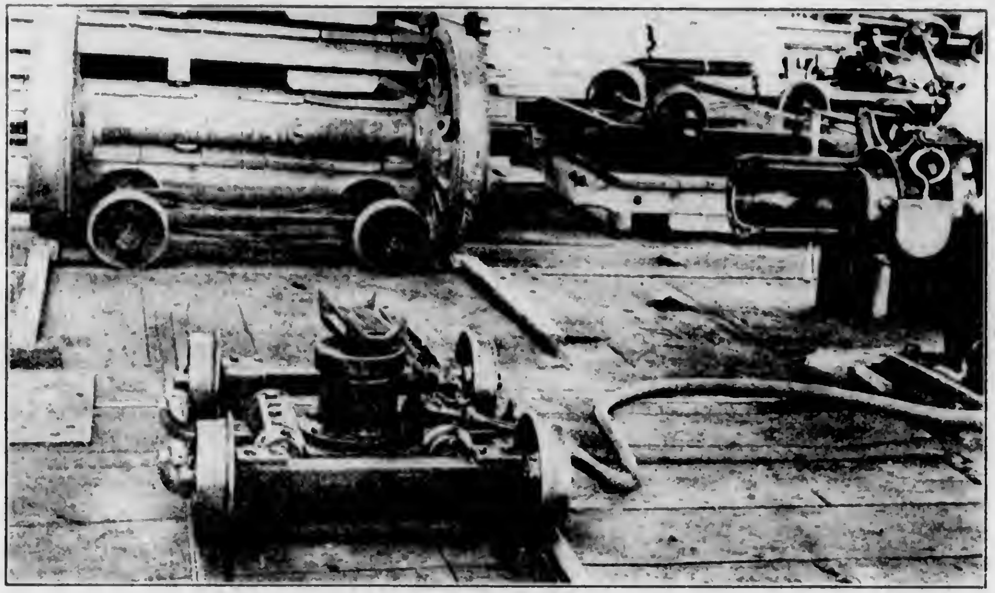


FIG. 19.—DOUBLE TRUCK FOR MOUNTING WHEELS AND AXLES, IN FOREGROUND. TRUCK FOR TRANSPORTING MOUNTED WHEELS AND AXLES ACROSS THE SHOP, IN THE REAR. IMPROVED SLEEVE ON THE PRESS AT THE RIGHT.

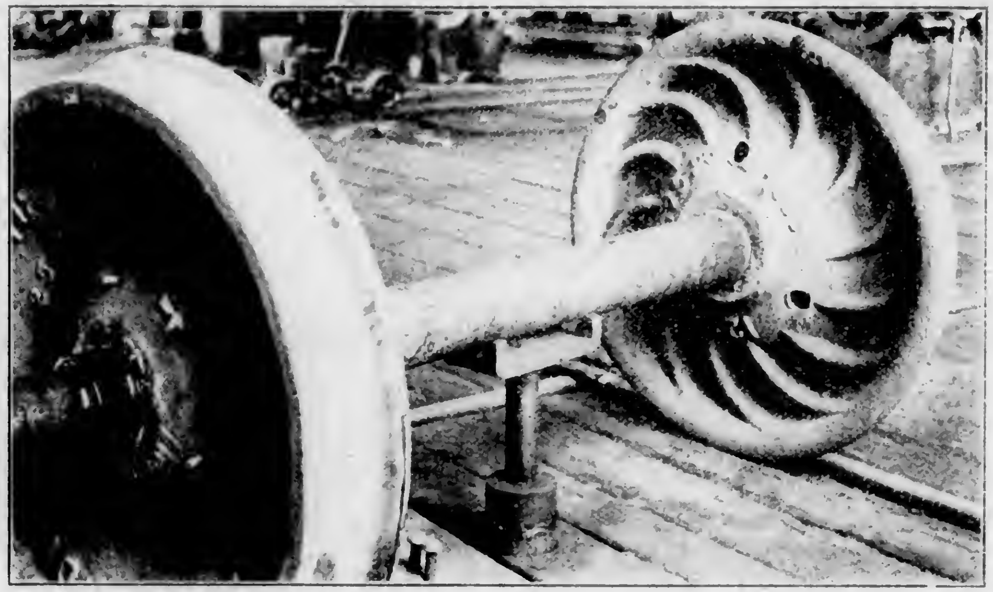


FIG. 20.—DEVICE FOR TURNING MOUNTED WHEELS OR LORRY TRUCKS—USED IN PLACE OF A TURNTABLE.

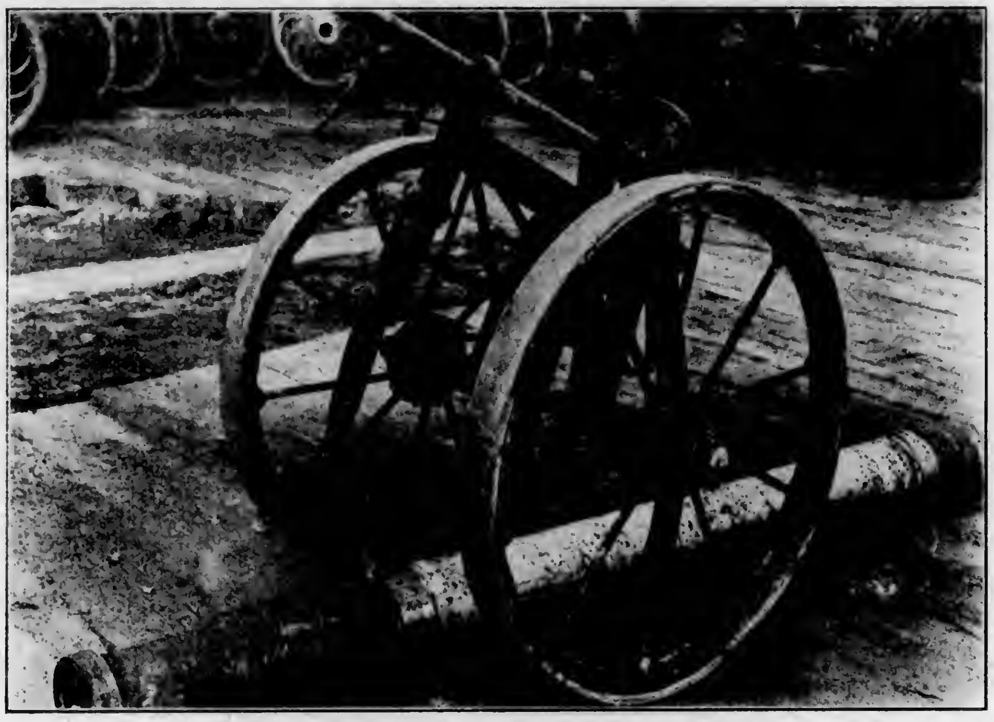


FIG. 14.—TRUCK FOR HANDLING AXLES.

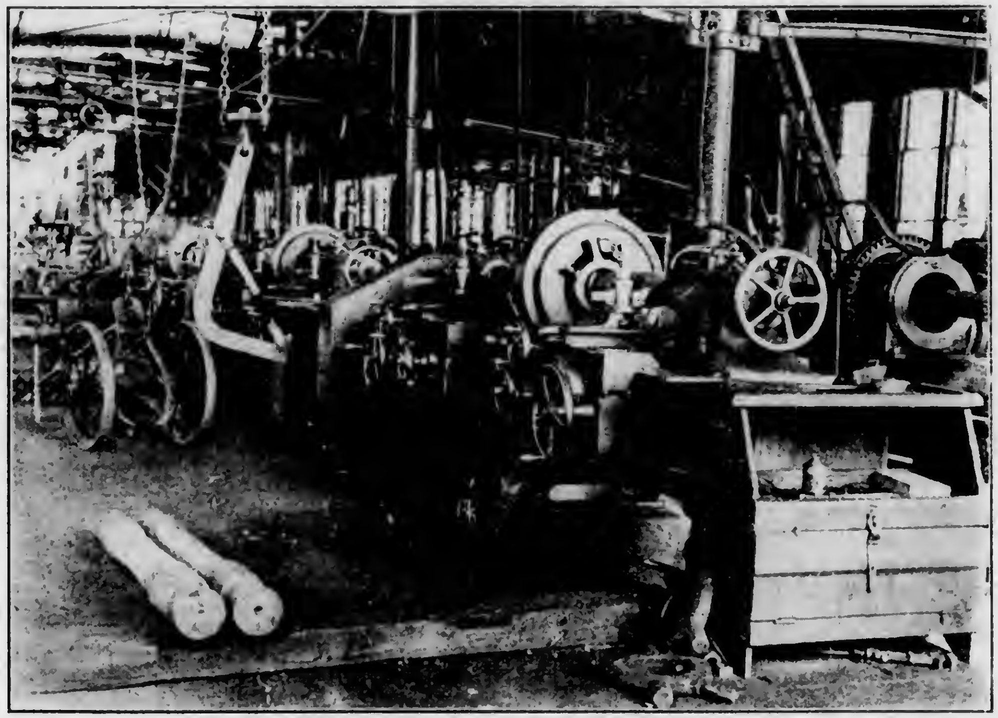


FIG. 15.—A GROUP OF AXLE LATHES WITH AXLE HANDLING TRUCK AT THE LEFT.

FIG. 17.—AIR HOIST IN WHEEL SHOP.

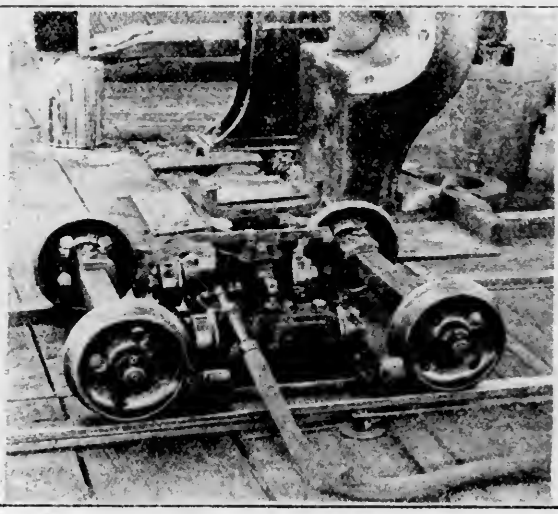


FIG. 18.—DOUBLE TRUCK AT THE WHEEL PRESS.

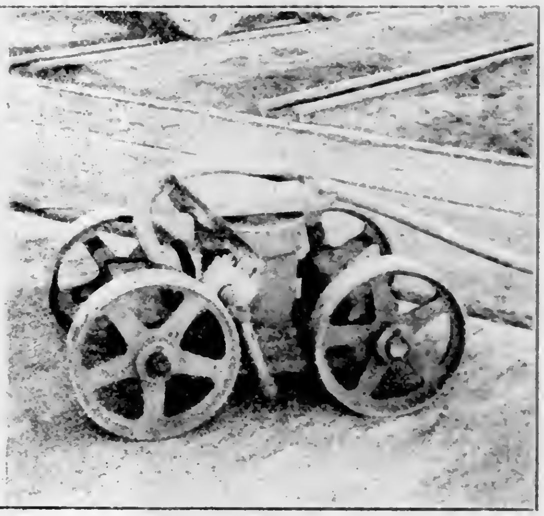


FIG. 21.—PORTABLE PNEUMATIC DEVICE FOR TURNING MOUNTED WHEELS.

from the crane in Fig. 15. To facilitate the picking up of axles with this device they are not laid flat on the floor, but are supported at one end by the plank shown in the foreground. The lathes rest upon concrete foundations (Fig. 16), each foundation being large enough to take two lathes, placed back to back. The cuttings and lubricating compound drop into a pit 14 in. deep, and the compound is drained into a cavity at the centre which contains a sheet iron tank. From this it is pumped back into circulation. The cuttings are cleaned out at regular intervals by laborers, and do not interfere at all with the operator.

These lathes are operated at high speed and to save time, when it is necessary to stop them, a brake, which is operated by the foot, has been placed on the large driving pulley, and quickly brings the machine to a stop. It is important to use cutting tools of a standard size in order that the workman may have as little difficulty as possible in changing from one to another. The shank of the burnishing tool has a pin passing through it which backs up against the tool post, and the only function the set-screw has to perform is to steady the tool. The operator does not have to screw it down nearly as tightly as when it is depended upon to keep the tool from slipping backward.

After the axles have been turned they are stored temporarily near the wheel presses. When ready to have wheels mounted upon them they are picked up by an air hoist, shown in Fig. 17, which operates on the overhead track, and are deposited upon the small truck shown in Figs. 18 and 19. It will be seen that the air hoist has a reservoir attached above it. This is to provide for the traveling back and forth of the hoist and to do away with having an extremely long hose. The reservoir is charged by running it under the charging device, shown in the illustration, it being only necessary to pull the chain, which is shown suspended, thus making an air-tight connection between the reservoir and the charging device and at the same time allowing air to flow into the reservoir. The reservoir has a capacity sufficient for the handling of 3 or 4 axles without re-charging.

The truck upon which the axle is placed preparatory to mounting, Figs. 18 and 19, consists practically of a double truck, the lower portion having a forward and backward movement, and the upper a sidewise motion. As soon as the axle has been placed upon it and the wheel seat has been white leaded, one of the wheels is rolled alongside the truck and the end of the axle is slipped into it by moving the upper part of the axle truck sidewise. The second wheel is then brought forward, and by pressing the lever lightly with the foot air is admitted to the cylinder and the plunger is forced upward raising the end of the axle sufficiently so that the wheel may be slipped over the end. The plunger is then raised to its full height and the truck is moved forward under the wheel press. The wheel press is fitted with a recording pressure gauge as well as with an ordinary gauge. The pressures required for applying wheels for cars and tenders are as follows:

PRESSURES FOR APPLYING WHEELS TO AXLES.

Size of Journals.	Standard Diameter of Wheel Fit.	Cast Iron Wheels	Steel Tired Wheels.
3¾ x 7	5½	30 to 40 tons	45 to 55 tons
4¼ x 8	5¾	35 to 45 "	50 to 60 "
5 x 9	6¼	40 to 50 "	60 to 70 "
5½ x 10	7	45 to 55 "	65 to 75 "

An interesting improvement has been made to the wheel press, which adds greatly to its usefulness. Instead of having the sleeve hung from the cross bar it has been fastened on the end of the ram and can be rotated by means of the two handles. While the wheels are being pressed on it is held securely in position by a set screw, but afterward when it is necessary to swing the mounted wheels around in order to place them on the track in the rear of the press, the set screw is loosened and the sleeve revolved 180 degrees, allowing the axle to swing back.

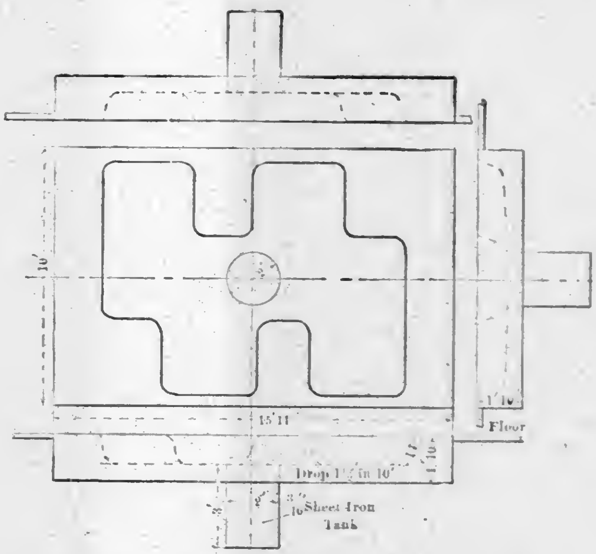


FIG. 16.—CONCRETE FOUNDATIONS FOR AXLE LATHES.

Another characteristic improvement is that the block, which is placed between the end of the axle and the ram, is hung from a hook instead of being left to lie on the floor, and is therefore always at hand when required. The mounted wheels after they have been swung back of the press are run on the wheel truck, shown in Fig. 19, and are moved to one of the tracks running lengthwise through the shop, depending upon whether they are to be used at once in the truck shop or are to be shipped or stored outside of the shop.

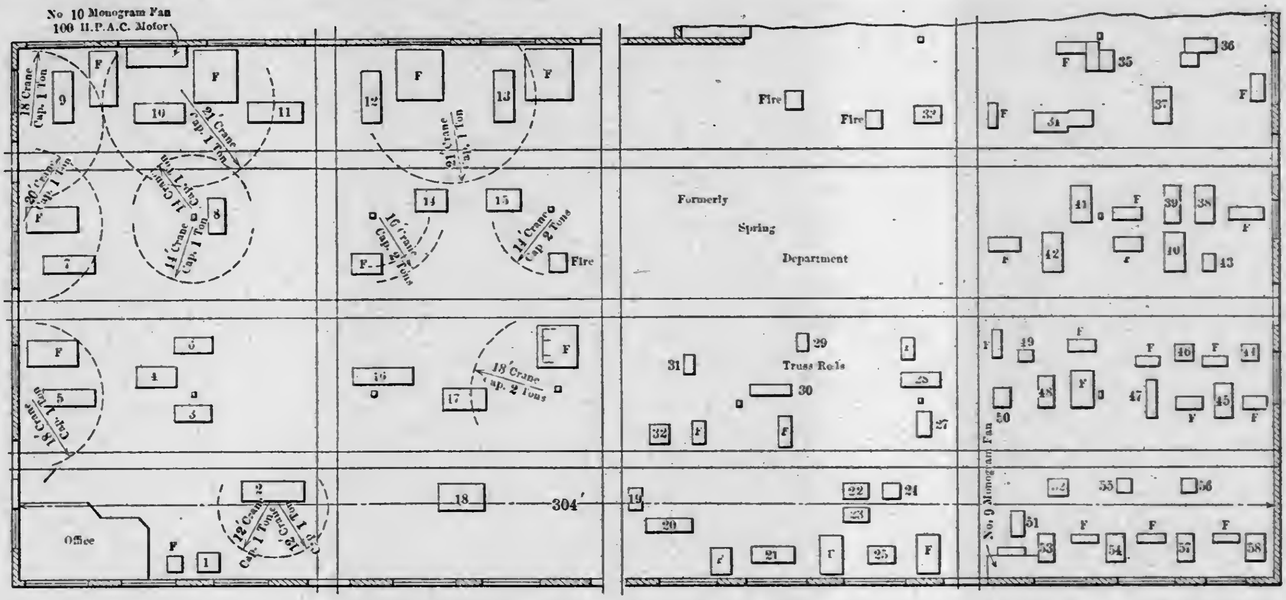
Another interesting device, which is not only used extensively in the shops in place of turntables, but is also used in a modified form throughout the yards where it is not advisable to use turntables because heavy cars and locomotives must operate over the

FIG. 23.—MATERIAL FOR BLACKSMITH SHOP USE.

FIG. 24.—AJAX BRAKE LEVER ROLLS.

FIG. 25.—REAR VIEW OF AJAX BRAKE LEVER ROLLS. SHEAR FOR ROUNDING ENDS AT LEFT SIDE.

FIG. 26.—PART OF THE TRUSS ROD DEPARTMENT IN THE SMITH SHOP.



F—FURNACES
1. Ajax Bending Rolls
2. Punch and Shears
3. Punch and Shears
4. Bulldozer, Cold
5. Bulldozer
6. Punch and Shears
7. Bulldozer
8. Punch and Shears
9. Bulldozer
10. Bulldozer
11. Bulldozer
12. Bulldozer
13. Bulldozer
14. 2,000-lb. Hammer
15. 1,200-lb. Hammer
16. Punch and Shears
17. 2,000-lb. Hammer
18. 600-lb. Hammer
19. Scale
20. 3-in. Forging Machine
21. 1½-in. Nut Machine
22. 1½-in. Nut Machine
23. 1½-in. Nut Machine
24. Scale
25. ⅝-in. Nut Machine
27. Single Shears
28. 2-in. Upsetting Machine
29. 2-in. Bolt Cutter
30. 2-in. Upsetting Machine
31. 2-in. Bolt Cutter
32. Pneumatic Riveter
33. Flat Iron Saw
34. No. 9 Monogram Fan
35. 200-lb. Beaudry Hammer
36. 350-lb. Beaudry Hammer
37. Punch and Shears
38. 100-lb. Bradley Hammer
39. 100-lb. Bradley Hammer
40. 100-lb. Bradley Hammer
41. 100-lb. Bradley Hammer
42. 200-lb. Bradley Hammer
43. Light Pneumatic Bulldozer
44. Eye Bolt Machine
45. 1½-in. Bolt Header
46. Eye Bolt Machine
47. 2-in. Forging Machine
48. 1½-in. Rivet Machine
49. Forging Machine
50. Bolt Header
51. Bolt Header
52. Round Iron Shears
53. 1½-in. Bolt Header
54. 1½-in. Bolt Header
55. Round Iron Shears
56. Round Iron Shears
57. 1½-in. Bolt Header
58. 2-in. Bolt Header

FIG. 22.—PLAN OF THE BLACKSMITH SHOP FOR THE CAR DEPARTMENT.

track, is shown in Fig. 20. By pressing one of the pins air is admitted to the air cylinder and the piston is forced upward, allowing the wheels or lorry truck to be swung around; by pressing the other pin the air is released.

Another device, quite similar to the one above described, is shown in Fig. 21. It is often necessary to store mounted wheels on tracks at right angles to the one on which they are brought out of the shop, and it would hardly be advisable to install a lot of turntables for turning them; it is an awkward job to do it by hand and requires two men. The truck shown can easily be moved to any point in the yard and the air hose run to the nearest connection. It is only necessary to roll the wheels over the truck, press the lever down with the foot to admit air to the cylinder, and swing the wheels around, release the air, and run them off on to the side track.

Gray Iron Foundry.

All of the gray iron castings for the locomotive and car departments are made in the foundry, which lies alongside of the locomotive shop, with one end facing the midway. As a number of improvements are at present being made in the equipment and operation of this foundry it will not be considered at length, but will be taken up in detail in connection with a study of the passenger car department, which we expect to present later. The castings are delivered from the foundry to the storage bins at the truck shop and freight car shop on lorry cars, over the tracks shown on the general plan. Castings for shipment to outside points are transferred to the storehouse.

The Smith Shop.*

The wing of the blacksmith shop, directly opposite the car machine shop, is devoted entirely to work for the car department. It is about 130 ft. wide by 304 ft. in length. The output of this part of the shop averages 180 tons per day and eight trucks, four men to a truck, are required for handling the material to the machines and delivering it to the shops where it is to be finished or applied. There are numerous doors in the building and the raw material is stored just outside the shop and as near the machine, where it is to be forged, as possible.

It is the practice to order the iron and steel cut to length for the various purposes for which it is to be used. This simplifies the problem of storing it to advantage and cuts out considerable rehandling of material, greatly facilitating the progress of the work through the shop. About 5,000 lbs. of wrought iron or mild steel are used in each 30-ton standard box car and at the rate of 28 or 30 cars per day, the work of the smith shop must be carefully planned to cut out lost motion in order to keep up the output for these cars, in addition to that for the passenger car department and for shipment to outside points.

Along the northern side of this building is a shed (indistinctly shown in the background at the left in Fig. 38), under which a large amount of material is stored for use in machines along that side of the shop. One is surprised at the extremely heavy construction of this shed, but when the heavy snowfall is considered, as well as the fact that the greater portion of the snow upon one side of the shop roof may be precipitated upon it, it is not to be wondered at. The more expensive material, including the tool steel, is stored in a 76 x 64 ft. frame building, east of the shop. A large amount of bar iron and rods are stored between the end of the shop and the reservoir, and just south of the reservoir. This storage yard is partially shown in Fig. 23. The wooden tablets showing the sizes of the iron are supported at the ends of rods and are at least four or five feet above the ground, thus making it possible to locate the material after a heavy snowfall.

A plan view of the car blacksmith shop is shown in Fig. 22. Coming into the shop, at the end nearest the power house, one is first attracted by the Ajax brake lever rolls, which are shown in Figs. 24 and 25. The dies are made adjustable, so that by unscrewing three screws and screwing up three on the opposite side the eccentric on the upper roll is changed. The same can also be done on the lower roll, which gauges the length of the taper to be rolled. The thickness of the lever may be changed as much as ⅜ in. by raising the upper roll. The machine is fitted with a shear, at the side, for rounding the ends of the levers. From 500 to 750 levers can be made in a day of ten hours.

* For details of the construction of the smith shop see pages 5 of the January, and 37 of the February, 1905, issues. The arrangement and equipment, at the time it was first put in service, are described on page 363 of the October, 1905, issue.

FIG. 23.—MATERIAL FOR BLACKSMITH SHOP.

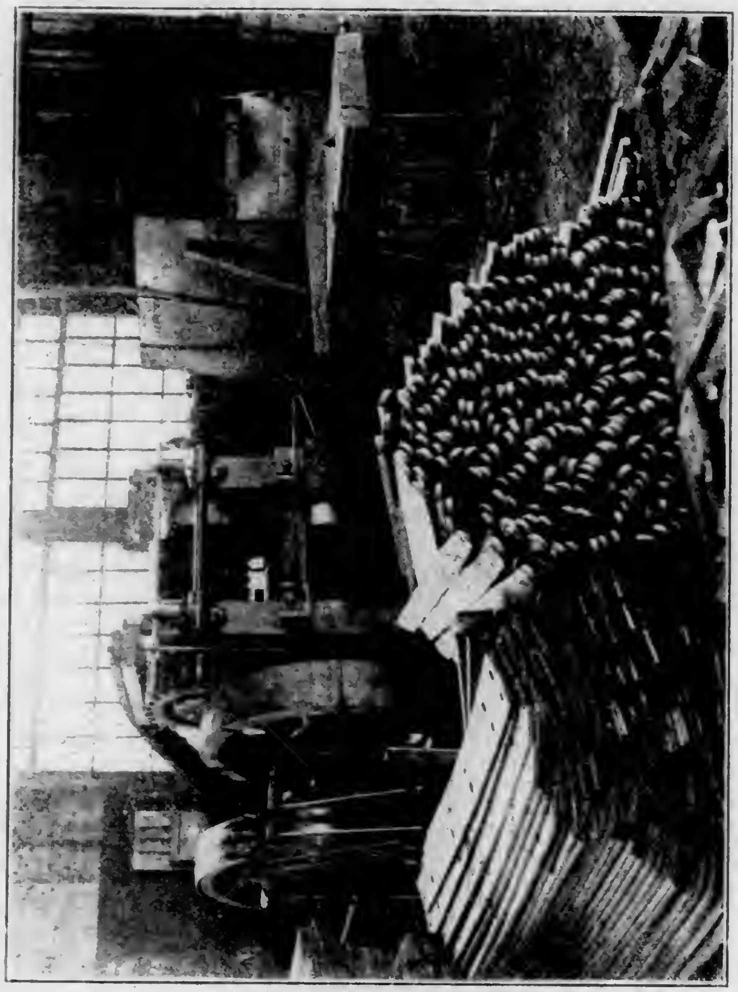


FIG. 24.—AJAX BRAKE LEVER ROLLS.

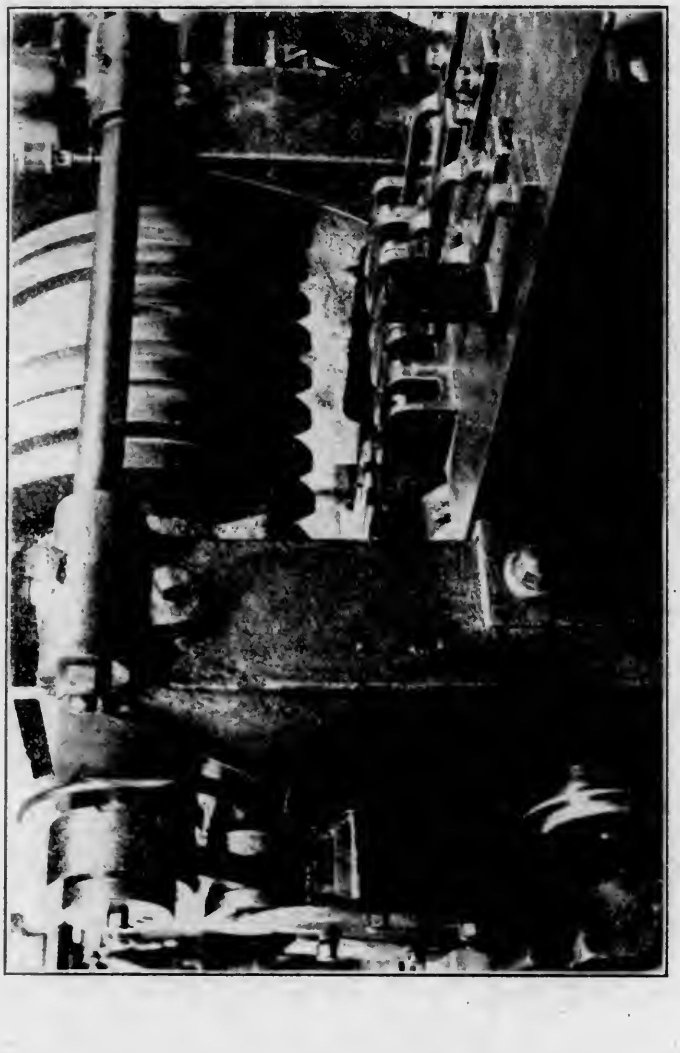


FIG. 25.—REAR VIEW OF AJAX BRAKE LEVER ROLLS. SHEAR FOR ROUNDING ENDS AT LEFT SIDE.

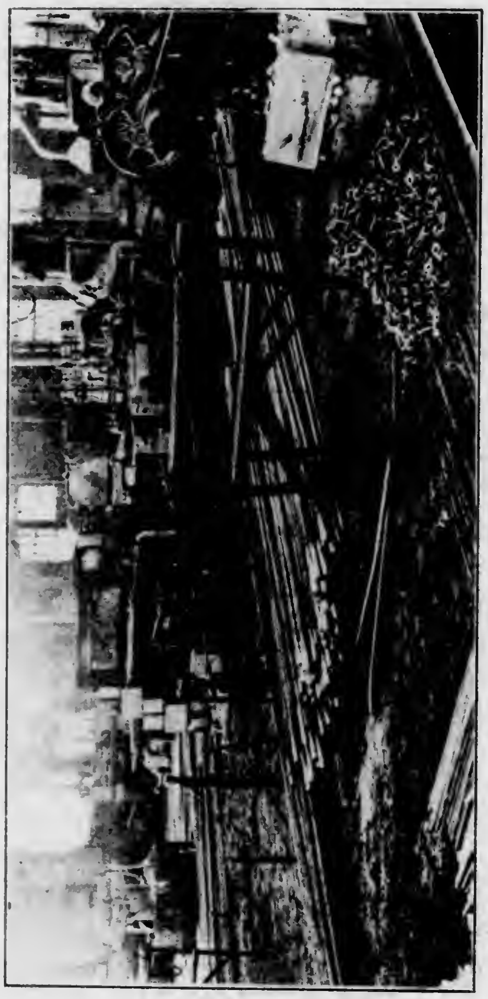
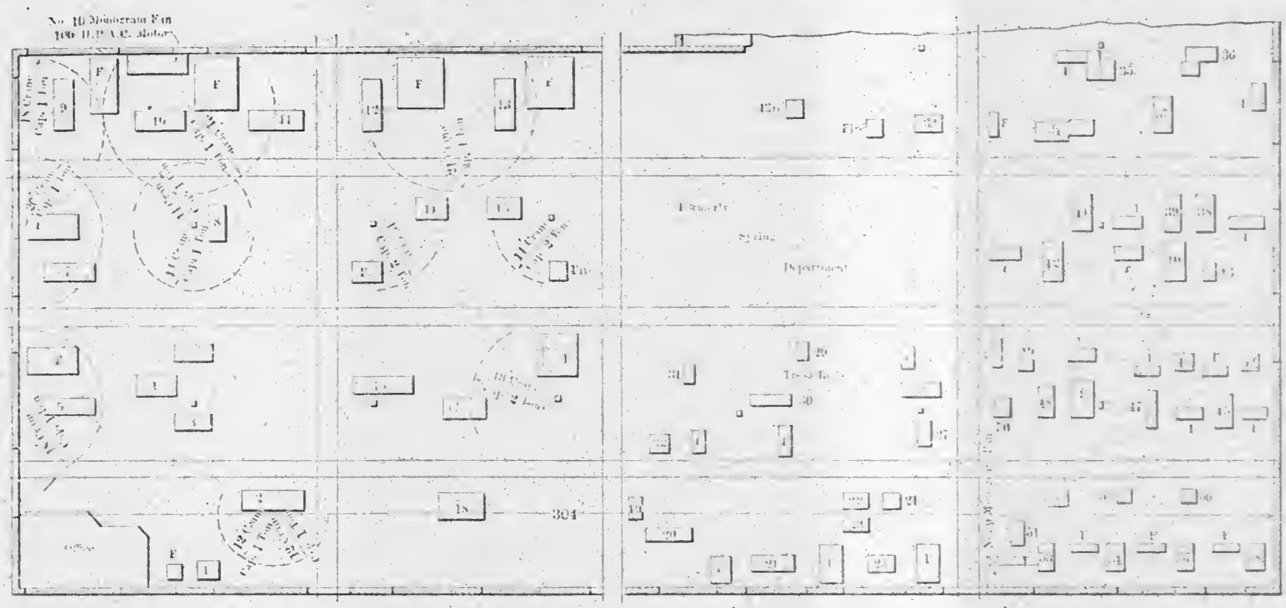


FIG. 26.—PART OF THE TRUSS ROD DEPARTMENT IN THE SMITH SHOP.



F Furnaces
1. Ajax Bending Rolls
2. Punch and Shears
3. Punch and Shears
4. Bulldozer, Cold
5. Bulldozer
6. Punch and Shears
7. Bulldozer
8. Punch and Shears
9. Bulldozer
10. Bulldozer
11. Bulldozer
12. Bulldozer
13. Bulldozer
14. 2,000-lb. Hammer
15. 1,200-lb. Hammer
16. Punch and Shears
17. 2,000-lb. Hammer
18. 600-lb. Hammer
19. Scale
20. 3-in. Forging Machine
21. 1½-in. Nut Machine
22. 1½-in. Nut Machine
23. 1½-in. Nut Machine
24. Scale
25. ⅝-in. Nut Machine
27. Single Shears
28. 2-in. Upsetting Machine
29. 2-in. Bolt Cutter
30. 2-in. Upsetting Machine
31. 2 in. Bolt Cutter
32. Pneumatic Riveter
33. Flat Iron Saw
34. No. 9 Monogram Fan
35. 200-lb. Beaudry Hammer
36. 350-lb. Beaudry Hammer
37. Punch and Shears
38. 100-lb. Bradley Hammer
39. 100-lb. Bradley Hammer
40. 100-lb. Bradley Hammer
41. 100-lb. Bradley Hammer
42. 200-lb. Bradley Hammer
43. Light Pneumatic Bulldozer
44. Eye Bolt Machine
45. 1½-in. Bolt Header
46. Eye Bolt Machine
47. 2-in. Forging Machine
48. 1½-in. Rivet Machine
49. Forging Machine
50. Bolt Header
51. Bolt Header
52. Round Iron Shears
53. 1½-in. Bolt Header
54. 1½-in. Bolt Header
55. Round Iron Shears
56. Round Iron Shears
57. 1½-in. Bolt Header
58. 2-in. Bolt Header

FIG. 22.—PLAN OF THE BLACKSMITH SHOP FOR THE CAR DEPARTMENT.

track, is shown in Fig. 20. By pressing one of the pins air is admitted to the air cylinder and the piston is forced upward, allowing the wheels or lorry truck to be swung around; by pressing the other pin the air is released.

Another device, quite similar to the one above described, is shown in Fig. 21. It is often necessary to store mounted wheels on tracks at right angles to the one on which they are brought out of the shop, and it would hardly be advisable to install a lot of turntables for turning them; it is an awkward job to do it by hand and requires two men. The truck shown can easily be moved to any point in the yard and the air hose run to the nearest connection. It is only necessary to roll the wheels over the truck, press the lever down with the foot to admit air to the cylinder, and swing the wheels around, release the air, and run them off on to the side track.

Gray Iron Foundry.

All of the gray iron castings for the locomotive and car departments are made in the foundry, which lies along-side of the locomotive shop, with one end facing the midway. As a number of improvements are at present being made in the equipment and operation of this foundry it will not be considered at length, but will be taken up in detail in connection with a study of the passenger car department, which we expect to present later. The castings are delivered from the foundry to the storage bins at the truck shop and freight car shop on lorry cars, over the tracks shown on the general plan. Castings for shipment to outside points are transferred to the storehouse.

The Smith Shop.*

The wing of the blacksmith shop, directly opposite the car machine shop, is devoted entirely to work for the car department. It is about 130 ft. wide by 304 ft. in length. The output of this part of the shop averages 180 tons per day and eight trucks, four men to a truck, are required for handling the material to the machines and delivering it to the shops where it is to be finished or applied. There are numerous doors in the building and the raw material is stored just outside the shop and as near the machine, where it is to be forged, as possible.

It is the practice to order the iron and steel cut to length for the various purposes for which it is to be used. This simplifies the problem of storing it to advantage and cuts out considerable rehandling of material, greatly facilitating the progress of the work through the shop. About 5,000 lbs. of wrought iron or mild steel are used in each 30-ton standard box car and at the rate of 28 or 30 cars per day, the work of the smith shop must be carefully planned to cut out lost motion in order to keep up the output for these cars, in addition to that for the passenger car department and for shipment to outside points.

Along the northern side of this building is a shed (indistinctly shown in the background at the left in Fig. 38), under which a large amount of material is stored for use in machines along that side of the shop. One is surprised at the extremely heavy construction of this shed, but when the heavy snowfall is considered, as well as the fact that the greater portion of the snow upon one side of the shop roof may be precipitated upon it, it is not to be wondered at. The more expensive material, including the tool steel, is stored in a 76 x 64 ft. frame building, east of the shop. A large amount of bar iron and rods are stored between the end of the shop and the reservoir, and just south of the reservoir. This storage yard is partially shown in Fig. 23. The wooden tablets showing the sizes of the iron are supported at the ends of rods and are at least four or five feet above the ground, thus making it possible to locate the material after a heavy snowfall.

A plan view of the car blacksmith shop is shown in Fig. 22. Coming into the shop, at the end nearest the power house, one is first attracted by the Ajax brake lever rolls, which are shown in Figs. 24 and 25. The dies are made adjustable, so that by unscrewing three screws and screwing up three on the opposite side the eccentric on the upper roll is changed. The same can also be done on the lower roll, which gauges the length of the taper to be rolled. The thickness of the lever may be changed as much as ⅝ in. by raising the upper roll. The machine is fitted with a shear, at the side, for rounding the ends of the levers. From 500 to 750 levers can be made in a day of ten hours.

* For details of the construction of the smith shop see pages 5 of the January, and 37 of the February, 1905, issues. The arrangement and equipment, at the time it was first put in service, are described on page 363 of the October, 1905, issue.

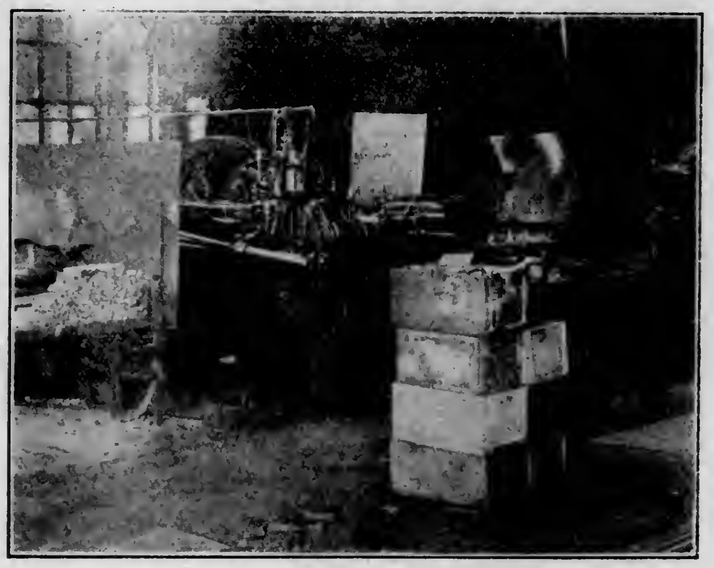


FIG. 27.—BOLT FORGING MACHINE, SHOWING THE CHUTE WHICH CONDUCTS THE FINISHED BOLTS TO A STEEL BOX SET IN THE FLOOR.

This end of the shop is fitted with several punches, shears and bulldozers. The bulldozer for forging arch bars has a centering attachment which adjusts the bar so that after being pressed both ends are symmetrical, regardless of any slight variation there may be in the length of the bars. One of the dies has a shallow blade which makes a mark at the centre of the bar, and this is used to facilitate the setting up of the bars when they are placed on the drilling machines in the machine shop. The six spindles of the drilling machine are set to template and the arch bar is quickly adjusted according to the mark at its centre.

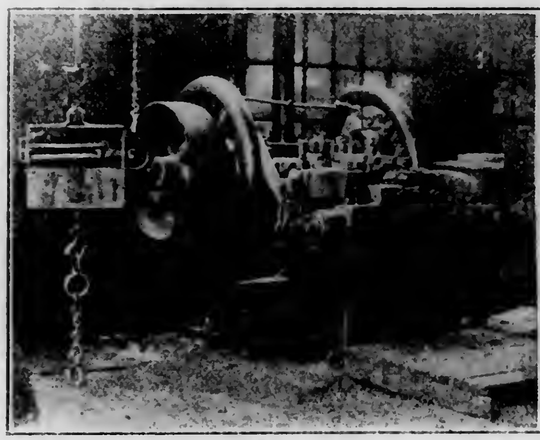


FIG. 28.—FORGING MACHINE AND SCALE ON THE HOIST FOR WEIGHING BOLTS.

FIG. 29.—STEEL BOXES FILLED WITH BOLTS AND READY TO BE TRANSFERRED TO THE MACHINE SHOP.

With the large number of truss rods which it is necessary to provide, considerable attention can be given to manufacturing them efficiently. A study of the plan will indicate that arrangements have been made to up-set both ends of the bar and thread them without turning the bar end to end. Two sets of furnaces, up-setting machines and bolt cutters, have been provided, as shown both on the plan (Fig. 22) and in Fig. 26.

The spring department is being removed to the new wing of the building and this space can now be used entirely for car department work.

One small department is given over to the manufacture of nuts and contains two nut machines, two burring machines and scales upon which the nuts are weighed, the piece workers' wages being based on these weights. The nuts are placed in boxes, before being weighed, and these are piled upon trucks and pushed through into the car machine shop, where the nuts are tapped. A similar feature is noticeable in connection with the manufacture of bolts. The bolts are dropped from the forging machine into steel buckets, shown in Fig. 27. These are hoisted by a crane and loaded on trucks and transported to the car machine shop, where the bolts are threaded. A scale is hung on a hoist (Fig. 28), and the bolts are weighed while they are being lifted from the machine to the truck, the piece workers' wages being based on these weights. A number of the boxes of bolts are shown in Fig. 29, as well as one of the Ajax forging machines. The bolt boxes are made of boiler plate. From the time the bolts and nuts are made until they are placed in the storage bins they do not touch the ground, but after each operation are dropped directly into the boxes or buckets. This reduces the cost of handling to a minimum. Fig. 30 shows a Williams & White eye-bolt machine, which is used for bending the ends of the brake hangers.

Car Machine Shop.*

Only that part of the car machine shop will be considered which is devoted to work used on freight cars, or that part which lies nearest the midway. The office of the superintendent of the car department is located upstairs at the northeast corner, and directly underneath it, and extending a considerable distance down the shop are the brass repair, cleaning and lacquer rooms. It is quite probable that this department will be removed to the new passenger shops when they are completed. The most noticeable features in connection with the operation of the car machine shop are the provisions for the comfort of the men and the facilities for turning out the work expeditiously. An idea of the out-

* For a description of the building see page 4 of the January, 1905, issue. The equipment and its arrangement are considered on page 114 of the April, 1905, issue.

FIG. 30.—EYE-BOLT MACHINE FOR BENDING THE ENDS OF THE BRAKE HANGERS.

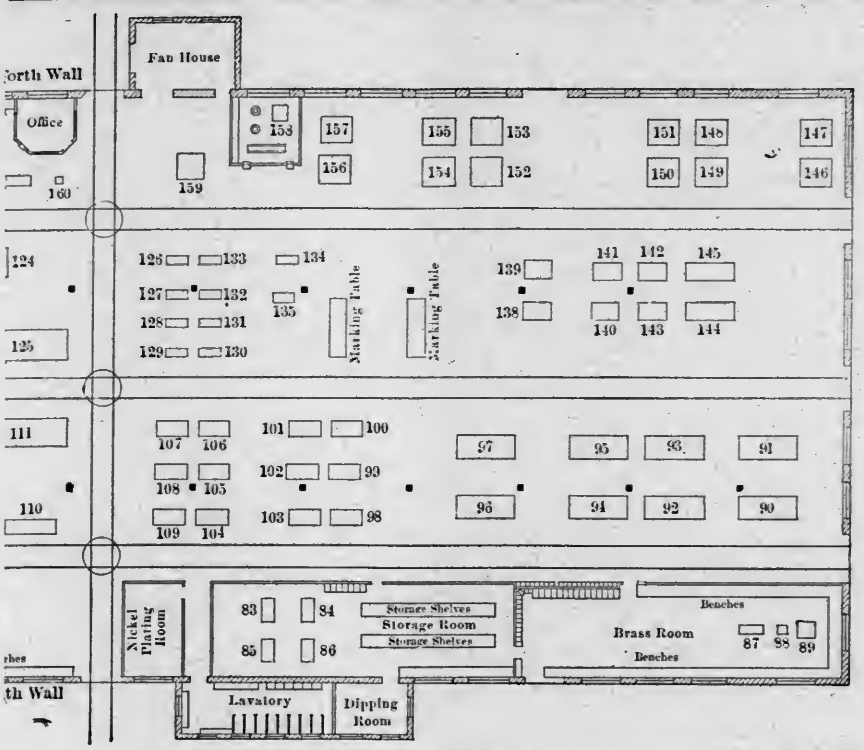


FIG. 31.—PARTIAL PLAN OF THE CAR MACHINE SHOP.

CAR MACHINE SHOP.

No.	Name and Maker.	Motor H. P.
83.	Double buffer	
84.	Double buffer	10
85.	Double buffer	
86.	Double buffer	
87.	¾-in turret lathe, Bertram & Sons	5
88.	16 in. sliding head drill press, Hamilton Machine Tool Company.	
89.	Miller, Smith & Coventry	
90.	6-spindle arch bar drill, Niles Tool Works	
91.	6-spindle arch bar drill, Bertram & Sons	
92.	6-spindle drill	
93.	6-spindle arch bar drill, Bertram & Sons	30
94.	6-spindle drill, Bertram & Sons	
95.	6-spindle drill, Bertram & Sons	
96.	6-spindle drill, Bertram & Sons	
97.	6-spindle drill, Bertram & Sons	
98.	32-in. vertical drill, Bertram & Sons	
99.	28-in. vertical drill, Cincinnati Machine Tool Company	
100.	25-in. vertical drill, Bertram & Sons	
101.	28-in. vertical drill, Cincinnati Machine Tool Company	
102.	28-in. vertical drill, Cincinnati Machine Tool Company	
103.	28-in. vertical drill, McGregor & Gourley	
104.	26-in. vertical drill, Prentice Bros.	15
105.	20-in. vertical drill, Prentiss	
106.	20-in. vertical drill	
107.	30.in. vertical drill	
108.	26-in. vertical drill, Bertram & Sons	
109.	25-in. vertical drill, Bertram & Sons	
126.	6-in. small vertical drill, C. P. R.	
127.	6-in. small vertical drill, C. P. R.	
128.	6-in. small vertical drill, C. P. R.	
129.	6-in. small vertical drill, C. P. R.	
130.	6-in. small vertical drill, C. P. R.	5
131.	6-in. small vertical drill, C. P. R.	
132.	6-in. small vertical drill, C. P. R.	
133.	8-in. small vertical drill, W. F. & T. Barnes Company	
134.	16-in. sliding head drill press, Hamilton Machine Tool Company.	
135.	16-in. sliding head drill press, Hamilton Machine Tool Company.	
138.	2-in. 6-spindle nut tapper, Acme Machine Company	
139.	2-in. 6-spindle nut tapper, Acme Machine Company	
140.	1½-in. 6-spindle nut tapper, Acme Machine Company	
141.	1-in. 6-spindle nut tapper, Acme Machine Company	
142.	1½-in. 4-spindle nut tapper	10
143.	1-in. 4-spindle nut tapper	
144.	1½-in. 6-spindle nut tapper	
145.	1½-in. 6-spindle nut tapper	
146.	1⅜-in. double bolt threader	
147.	1½-in. double bolt threader	
148.	1½-in. double bolt threader, A. R. Williams Machine Company	10
149.	1½-in. double bolt threader	
150.	1½-in. triple bolt threader, Bertram & Sons	
151.	1½-in. triple bolt threader, Bertram & Sons	
152.	1½-in. double bolt threader, National Machine Company	
153.	2-in. triple bolt threader, National Machine Company	
154.	1-in. double bolt threader	
155.	1½-in. double bolt threader, National Machine Company	
156.	2-in. triple bolt threader, Bertram & Sons	10
157.	2-in. triple bolt threader, Bertram & Sons	
158.	Drill grinder, Washburn Shops	
159.	Universal milling machine, No. 3, Cincinnati Milling Machine Company	
160.	Universal tool grinder, Cincinnati Milling Machine Company	

put of this shop may be gained from the fact that the store orders amount to more than the requirements at the Angus shops.

Three things are necessary to get the maximum output from a machine; a good machine; a good operator and good surroundings, including facilities for handling the work and for the comfort and convenience of the operators. Apparently all three of these have been given special attention. The machine tools are kept in an excellent state of repair; the material is handled in a neat and orderly manner; special facilities are provided for handling the work to and from the machines and clamping it in place; the operator's comfort and convenience have been studied and provided for. These features may best be emphasized by reference to the accompanying photographs.

The plan of that part of the shop in which most of the freight car parts are finished is shown in Fig. 31. Entering the door from the midway attention is first directed to the group of six-spindle drills, two of which are used entirely for drilling arch bars. One of the arch bar drills is shown in Fig. 32. Provision has been made for conducting the lubricating compound to a well from which it is circulated by a pump. The plank fastened to the front of the machine prevents the compound from splashing on the feet of the operator. In addition to this, and to prevent the compound gathering where the operator will be forced to step into it, a platform has been constructed as shown. Such of the compound or cuttings as may fall in front of the machine drop through the grating out of the way. The machine is provided with special facilities for quickly clamping the bars in place, as shown. Fig. 33 shows an arrangement which is used in connection with the drilling of steel wheel centres for passenger car work. The lubricating compound is drawn off through the funnels and drains to a well underneath, the same kind of floor for keeping the operator's feet dry being provided, as described above. A crane swings over this machine for hoisting the centres into place and they are held in a jig and drilled to template.

Provision for keeping the operators' feet dry and keeping the cuttings from under their feet has been made not only for the large machines, but also for the smaller ones, as shown in Fig. 34. The arrangement of this machine is similar to that of the other small drill presses and sensitive drills. The drill illustrated is used for drilling the cotter pin holes in brake beams. The pins are delivered from the blacksmith shop in boxes, shown alongside the machine, and the operator fills an empty box with the finished pins as he empties one of the others. That the provision for the men's comfort is appreciated is shown by the fact that they are careful to keep these features in good condition and repair.

In many of the iron freight car parts the holes are punched in the smith shop, but when they must be made to take pins, as in the brake lever jaws, etc., it is necessary to drill or ream them; there are also places where it is impossible to punch the holes. Usually the drills are fitted with clamping devices for holding the pieces so that the piece may be released or fastened in place with the tap of a hammer or pulling a lever. A jig for drilling the dead lever guides is fitted with a spacing device, the guide being shifted the proper distance between the holes by pulling a lever, marking off being thus made unnecessary.

Fig. 35 shows a row of nut tappers. The nuts are brought in from the blacksmith shop in the boxes, and as they are tapped they are dropped into a slide which carries them to the buckets back of the machines. The capacity of these buckets is just equal to that of one of the boxes. The machine in the foreground has not been equipped in this way, it being necessary for the operator to drop the nuts in the buckets in front of the machine. The other machines are, however, equipped in the same way as the one shown to the right. The boxes are weighed by a storehouse representative, and those which are to be shipped to outside points have covers nailed on them and are sent to the storehouse. Here also are seen the special platforms for keeping the operators' feet dry, the compound being drained off into wells underneath the machines.

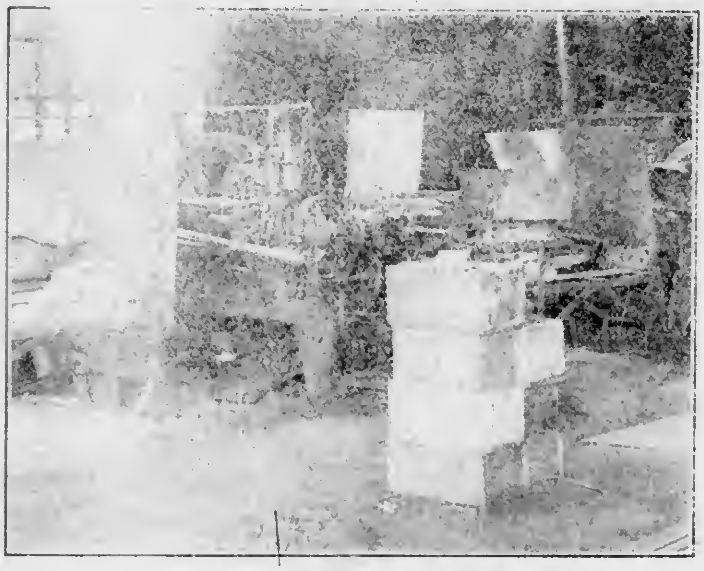


FIG. 27.—BOLT FORGING MACHINE, SHOWING THE CHUTE WHICH CONDUCTS THE FINISHED BOLTS TO A STEEL BOX SET IN THE FLOOR.

This end of the shop is fitted with several punches, shears and bulldozers. The bulldozer for forging arch bars has a centering attachment which adjusts the bar so that after being pressed both ends are symmetrical, regardless of any slight variation there may be in the length of the bars. One of the dies has a shallow blade which makes a mark at the centre of the bar, and this is used to facilitate the setting up of the bars when they are placed on the drilling machines in the machine shop. The six spindles of the drilling machine are set to template and the arch bar is quickly adjusted according to the mark at its centre.

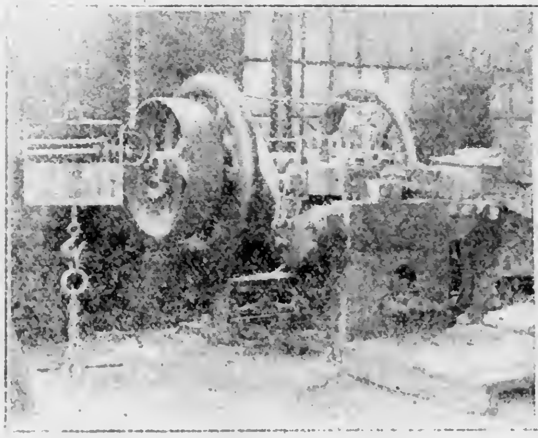


FIG. 28.—FORGING MACHINE AND SCALE ON THE HOIST, FOR WEIGHING BOLTS.

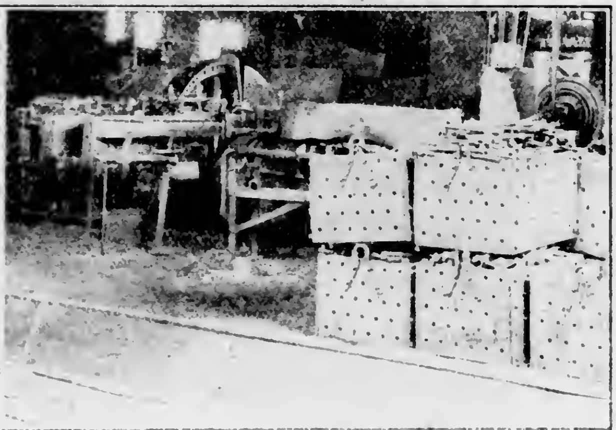


FIG. 29.—STEEL BOXES FILLED WITH BOLTS AND READY TO BE TRANSFERRED TO THE MACHINE SHOP.

With the large number of truss rods which it is necessary to provide, considerable attention can be given to manufacturing them efficiently. A study of the plan will indicate that arrangements have been made to upset both ends of the bar and thread them without turning the bar end to end. Two sets of furnaces, upsetting machines and bolt cutters, have been provided, as shown both on the plan (Fig. 22) and in Fig. 26.

The spring department is being removed to the new wing of the building and this space can now be used entirely for car department work.

One small department is given over to the manufacture of nuts and contains two nut machines, two burring machines and scales upon which the nuts are weighed, the piece workers' wages being based on these weights. The nuts are placed in boxes, before being weighed, and these are piled upon trucks and pushed through into the car machine shop, where the nuts are tapped. A similar feature is noticeable in connection with the manufacture of bolts. The bolts are dropped from the forging machine into steel buckets, shown in Fig. 27. These are hoisted by a crane and loaded on trucks and transported to the car machine shop, where the bolts are threaded. A scale is hung on a hoist (Fig. 28), and the bolts are weighed while they are being lifted from the machine to the truck, the piece workers' wages being based on these weights. A number of the boxes of bolts are shown in Fig. 29, as well as one of the Ajax forging machines. The bolt boxes are made of boiler plate. From the time the bolts and nuts are made until they are placed in the storage bins they do not touch the ground, but after each operation are dropped directly into the boxes or buckets. This reduces the cost of handling to a minimum. Fig. 30 shows a Williams & White eye-bolt machine, which is used for bending the ends of the brake hangers.

Car Machine Shop.*

Only that part of the car machine shop will be considered which is devoted to work used on freight cars, or that part which lies nearest the midway. The office of the superintendent of the car department is located upstairs at the northeast corner, and directly underneath it, and extending a considerable distance down the shop are the brass repair, cleaning and lacquer rooms. It is quite probable that this department will be removed to the new passenger shops when they are completed. The most noticeable features in connection with the operation of the car machine shop are the provisions for the comfort of the men and the facilities for turning out the work expeditiously. An idea of the out-

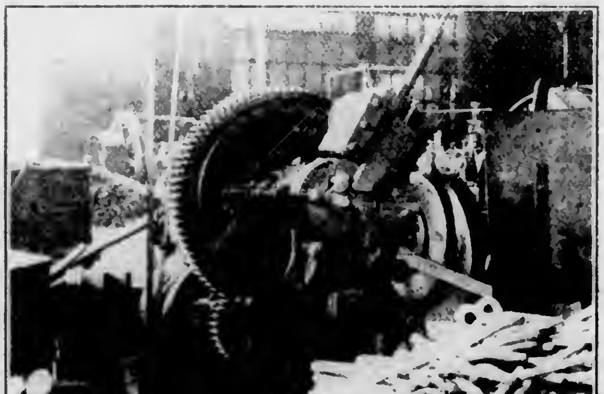


FIG. 30.—EYE-BOLT MACHINE FOR BENDING THE ENDS OF THE BRAKE HANGERS.

* For a description of the building see page 1 of the January, 1905, issue. The equipment and its arrangement are considered on page 111 of the April, 1905, issue.

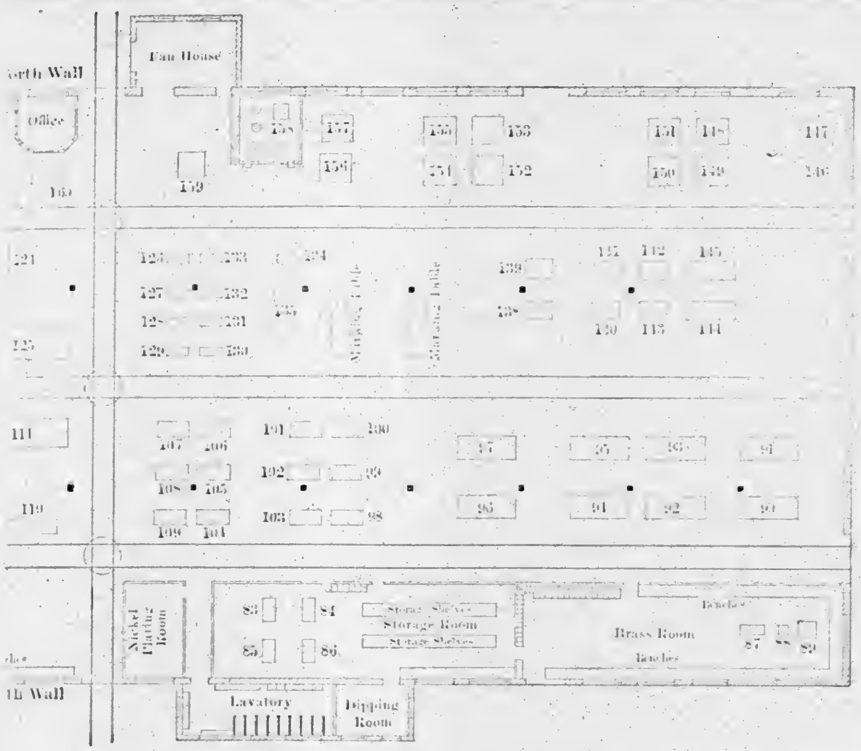


FIG. 31.—PARTIAL PLAN OF THE CAR MACHINE SHOP.

CAR MACHINE SHOP.

No.	Name and Maker.	Motor H. P.
83.	Double buffer	
84.	Double buffer	10
85.	Double buffer	
86.	Double buffer	
87.	¾-in. turret lathe, Bertram & Sons	5
88.	16-in. sliding head drill press, Hamilton Machine Tool Company.	
89.	Miller, Smith & Coventry	
90.	6-spindle arch bar drill, Niles Tool Works	
91.	6-spindle arch bar drill, Bertram & Sons	
92.	6-spindle drill	
93.	6-spindle arch bar drill, Bertram & Sons	30
94.	6-spindle drill, Bertram & Sons	
95.	6-spindle drill, Bertram & Sons	
96.	6-spindle drill, Bertram & Sons	
97.	6-spindle drill, Bertram & Sons	
98.	32-in. vertical drill, Bertram & Sons	
99.	28-in. vertical drill, Cincinnati Machine Tool Company	
100.	25-in. vertical drill, Bertram & Sons	
101.	28-in. vertical drill, Cincinnati Machine Tool Company	
102.	28-in. vertical drill, Cincinnati Machine Tool Company	
103.	28-in. vertical drill, McGregor & Gourlay	
104.	26-in. vertical drill, Prentice Bros.	15
105.	20-in. vertical drill, Prentiss	
106.	20-in. vertical drill	
107.	30-in. vertical drill	
108.	26-in. vertical drill, Bertram & Sons	
109.	25-in. vertical drill, Bertram & Sons	
126.	6-in. small vertical drill, C. P. R.	
127.	6-in. small vertical drill, C. P. R.	
128.	6-in. small vertical drill, C. P. R.	
129.	6-in. small vertical drill, C. P. R.	
130.	6-in. small vertical drill, C. P. R.	5
131.	6-in. small vertical drill, C. P. R.	
132.	6-in. small vertical drill, C. P. R.	
133.	8-in. small vertical drill, W. F. & J. Barnes Company	
134.	16-in. sliding head drill press, Hamilton Machine Tool Company	
135.	16-in. sliding head drill press, Hamilton Machine Tool Company.	
138.	2-in. 6-spindle nut tapper, Acme Machine Company	
139.	2-in. 6-spindle nut tapper, Acme Machine Company	
140.	1½-in. 6-spindle nut tapper, Acme Machine Company	
141.	1-in. 6-spindle nut tapper, Acme Machine Company	
142.	1½-in. 4-spindle nut tapper	10
143.	1-in. 4-spindle nut tapper	
144.	1½-in. 6-spindle nut tapper	
145.	1½-in. 6-spindle nut tapper	
146.	1⅜-in. double bolt threader	
147.	1½-in. double bolt threader	
148.	1½-in. double bolt threader, A. R. Williams Machine Company	10
149.	1½-in. double bolt threader	
150.	1½-in. triple bolt threader, Bertram & Sons	
151.	1½-in. triple bolt threader, Bertram & Sons	
152.	1½-in. double bolt threader, National Machine Company	
153.	2-in. triple bolt threader, National Machine Company	
154.	1-in. double bolt threader	
155.	1½-in. double bolt threader, National Machine Company	
156.	2-in. triple bolt threader, Bertram & Sons	10
157.	2-in. triple bolt threader, Bertram & Sons	
158.	Drill grinder, Washburn Shops	
159.	Universal milling machine, No. 3, Cincinnati Milling Machine Company	
160.	Universal tool grinder, Cincinnati Milling Machine Company	

put of this shop may be gained from the fact that the store orders amount to more than the requirements at the Angus shops.

Three things are necessary to get the maximum output from a machine: a good machine; a good operator and good surroundings, including facilities for handling the work and for the comfort and convenience of the operators. Apparently all three of these have been given special attention. The machine tools are kept in an excellent state of repair; the material is handled in a neat and orderly manner; special facilities are provided for handling the work to and from the machines and clamping it in place; the operator's comfort and convenience have been studied and provided for. These features may best be emphasized by reference to the accompanying photographs.

The plan of that part of the shop in which most of the freight car parts are machined is shown in Fig. 31. Entering the door from the yard, attention is first directed to the group of six-spindle drills, two of which are used entirely for drilling arch bars. One of the arch bar drills is shown in Fig. 32. Provision has been made for conducting the lubricating compound to a well from which it is circulated by a pump. The plank fastened to the front of the machine prevents the compound from splashing on the feet of the operator. In addition to this, and to prevent the compound gathering where the operator will be forced to step into it, a platform has been constructed as shown. Such of the compound or cuttings as may fall in front of the machine drop through the grating out of the way. The machine is provided with special facilities for quickly clamping the bars in place, as shown. Fig. 33 shows an arrangement which is used in connection with the drilling of steel wheel centres for passenger car work. The lubricating compound is drawn off through the funnels and drains to a well underneath, the same kind of floor for keeping the operator's feet dry being provided, as described above. A crane swings over this machine for hoisting the centres into place and they are held in a jig and drilled to template.

Provision for keeping the operators' feet dry and keeping the cuttings from under their feet has been made not only for the large machines, but also for the smaller ones, as shown in Fig. 34. The arrangement of this machine is similar to that of the other small drill presses and sensitive drills. The drill illustrated is used for drilling the cotter pin holes in brake levers. The pins are delivered from the blacksmith shop in boxes, shown alongside the machine, and the operator fills an empty box with the finished pins as he empties one of the others. That this provision for the men's comfort is appreciated is shown by the fact that they are careful to keep these features in good condition and repair.

In many of the iron freight car parts the holes are punched in the smith shop, but when they must be made to take pins, as in the brake lever jaws, etc., it is necessary to drill or ream them; there are also places where it is impossible to punch the holes. Usually the drills are fitted with clamping devices for holding the pieces so that the piece may be released or fastened in place with the tap of a hammer or pulling a lever. A jig for drilling the dead lever guides is fitted with a spacing device, the guide being shifted the proper distance between the holes by pulling a lever, marking off being thus made unnecessary.

Fig. 35 shows a row of nut tappers. The nuts are brought in from the blacksmith shop in the boxes, and as they are tapped they are dropped into a slide which carries them to the buckets back of the machines. The capacity of these buckets is just equal to that of one of the boxes. The machine in the foreground has not been equipped in this way, it being necessary for the operator to drop the nuts in the buckets in front of the machine. The other machines are, however, equipped in the same way as the one shown to the right. The boxes are weighed by a storehouse representative, and those which are to be shipped to outside points have covers nailed on them and are sent to the storehouse. Here also are seen the special platforms for keeping the operators' feet dry, the compound being drained off into wells underneath the machines.

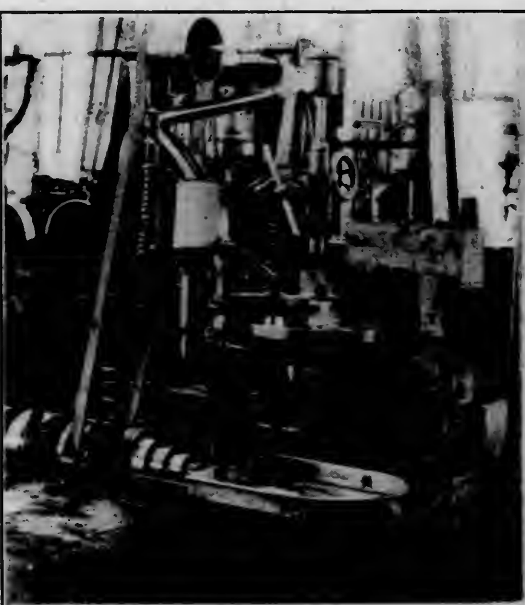


FIG. 34

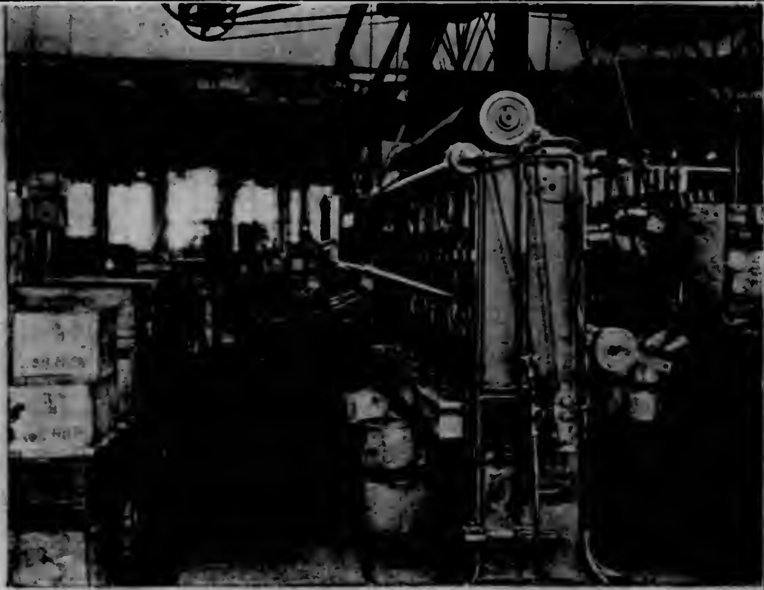


FIG 35

FIG. 33

FIG 36

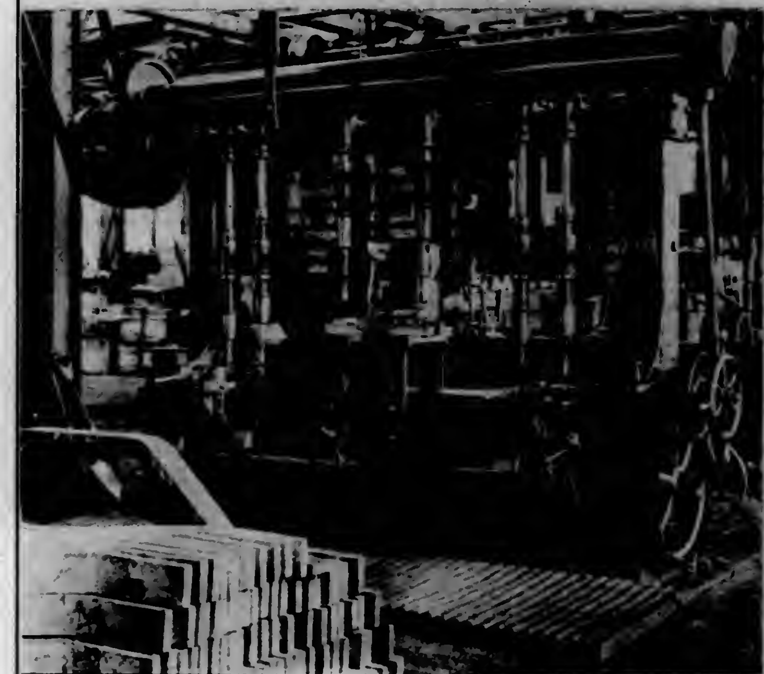


FIG 32

FIG. 37

FIG. 32.—SIX-SPINDLE ARCH BAR DRILL.

FIG. 33.—SIX-SPINDLE DRILL USED FOR STEEL PASSENGER CAR WHEEL CENTERS.

FIG. 34.—SENSITIVE DRILL USED FOR DRILLING COTTER PIN HOLES IN BRAKE PINS.

FIG. 35.—NUT TAPPING DEPARTMENT.

FIG. 36.—STEEL BOLT BOXES. BOLT THREADER IN THE REAR.

FIG. 37.—PNEUMATIC HAMMER FOR RIVETING FIXTURES TO STEEL END DOOR OF BOX CARS.

Along the north side of the shop are a number of bolt cutters. The bolts are brought in from the blacksmith shop in the iron boxes, shown in Figs. 27, 29 and 36, and are unloaded by a crane and placed convenient to the machine upon which they are to be threaded. As the bolts are threaded they are thrown into an empty box, and when this is filled it is placed with others on a truck and delivered to the storehouse or to the shop in which they are to be used. The rods for the framing of the box cars are also threaded in this department.

An interesting home-made device is used for riveting the different parts on the iron end doors of the standard box car. It consists of the body of an old long stroke air hammer attached to a frame, as shown in Fig. 37. Rivets are driven cold. As the treadle is pressed down the end of the hammer is brought down on the head of the rivet and is placed in operation.

Such material as is not brought directly into the car machine shop is stored outside at the most convenient point to the machine upon which it is to be finished. For instance, the rods which are used in the framing of the box cars, are stored along the north side of the machine shop, nearest to the bolt cutting machines. It is important in handling the large amount of this material to keep from getting the different size rods mixed and a very simple precaution has been taken to prevent this, as shown in Fig. 38. In addition to having the size plainly stencilled on the front of the bin the back of the bin is adjusted for the length of the rod which is to be placed in it, and as the rods are piled they are pushed back until they come in contact with the back. If the wrong length is put in a bin it immediately becomes noticeable. A clear passageway has been left between the back of the bin and the side of the building, and while this may seem a waste of space, yet it is possible to keep the surroundings much neater and cleaner than under other conditions.

FIG. 38.—STORAGE BINS FOR RODS OUTSIDE OF MACHINE SHOP. STORAGE SHED ALONGSIDE THE BLACKSMITH SHOP IN THE REAR.
FIG. 39.—ERECTING TRACK IN TRUCK SHOP.

FIG. 44.—GARRY PNEUMATIC CRANE FOR UNLOADING BOLSTERS, ETC.

Truck Shop.

One end of the wheel shop is used for finishing the wheels and axles and mounting them, as has been described. The remaining portion is devoted to the building and repairing of passenger car trucks and the building of freight car trucks. When the freight car shop is engaged in building box or refrigerator cars, only one track is used for building trucks, but when an order of flat cars is being built it is necessary to use two tracks. The truck gang, for an output of 28 standard 30-ton box cars per day, consists of seven men, including the foreman.

The mounted wheels are rolled on at one end of the track. The truck advances from one stage of construction to another, the material being piled at the proper place alongside the track, and each man having certain parts of the work which he must perform. The men are paid on a piece-work basis, and if one man slows up his associates see to it that he makes up for lost time, for the output of the entire gang will suffer. In like manner, if one man has difficulty in adjusting a part, the others see to it that he is given proper assistance. The gang works like a machine, except that intelligence is combined with energy, and if one part becomes clogged the energies of part of the gang are momentarily concentrated at that point until the difficulty is overcome.

The results are astonishing. Fifty-six trucks per day, or at the rate of eight for every man, including the foreman, or charge-hand, is doing a good day's work, and the men are not in an exhausted condition by any means when the whistle blows. It is the result of carefully planned and specialized work. It also requires the prompt delivery of material and that it be arranged and piled properly. It is the foreman's or charge-hand's duty to watch the delivery of material and oversee and assist the men.

The accompanying photographs, showing the truck in different stages of erection, will assist in making the work of this department clear.

The wheels, after they are mounted, are placed on the track upon which the trucks are erected, as shown in Fig. 39. The journal boxes are fitted with dust guards and are placed on the journals by a helper, who devotes only a small portion of his time to this work. The journal boxes are stored in a large quantity alongside the track and additional storage room is provided just outside of the shop.

When the wheels in this condition are moved forward to a certain point two of the truck gang come back and fit the journal brasses and wedges in place. The wheels are then moved forward and the lower arch bar is placed on the boxes and the two column castings are placed on the sloping part of the bar. The sand plank (the brake hanger brackets are riveted to the sand plank in the smith shop) is then swung into place with a crane and the short bolts which connect it to the column castings are put in

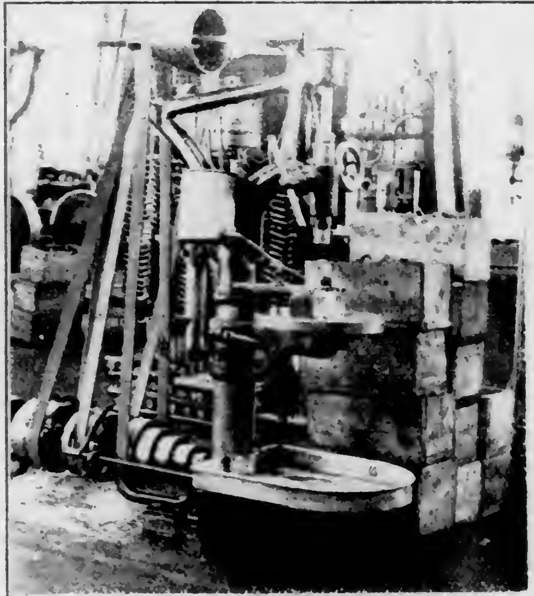


FIG 34

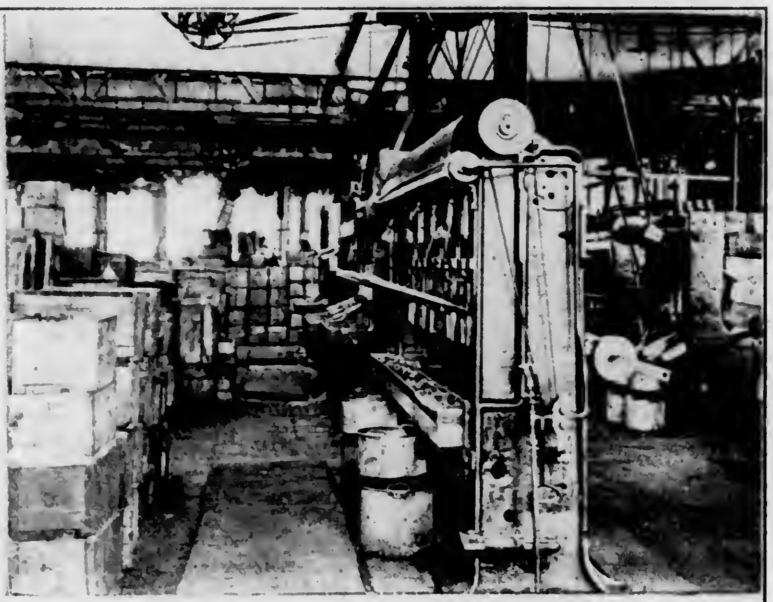


FIG 35

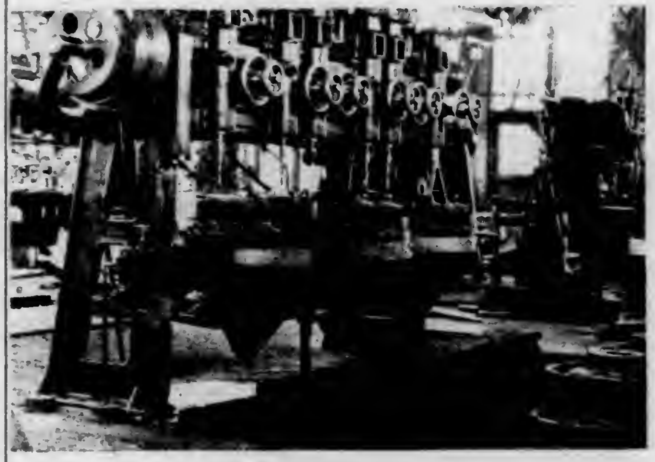


FIG. 33

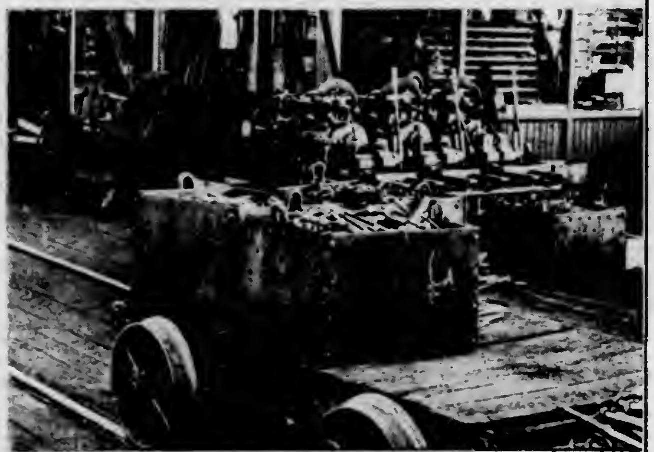


FIG 36

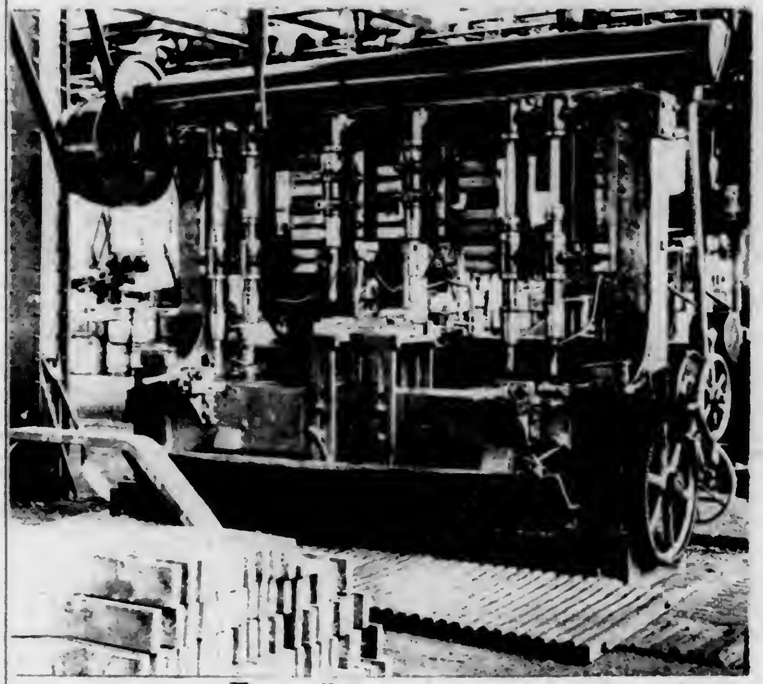


FIG 32

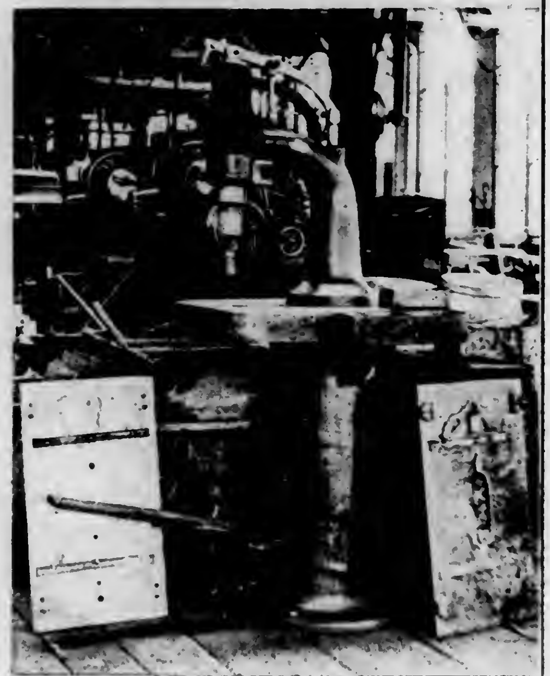


FIG. 37

FIG. 32.—SIX-SPINDLE ARCH BAR DRILL.

FIG. 33.—SIX-SPINDLE DRILL USED FOR STEEL PASSENGER CAR WHEEL CENTERS.

FIG. 34.—SENSITIVE DRILL USED FOR DRILLING COTTER PIN HOLES IN BRAKE PINS.

FIG. 35.—NUT TAPPING DEPARTMENT.

FIG. 36.—STEEL BOLT BOXES. BOLT THREADER IN THE REAR.

FIG. 37.—PNEUMATIC HAMMER FOR RIVETING FIXTURES TO STEEL END DOOR OF BOX CARS.

Along the north side of the shop are a number of bolt cutters. The bolts are brought in from the blacksmith shop in the iron boxes, shown in Figs. 27, 29 and 30, and are unloaded by a crane and placed convenient to the machine upon which they are to be threaded. As the bolts are threaded they are thrown into an empty box, and when this is filled it is placed with others on a truck and delivered to the storehouse or to the shop in which they are to be used. The rods for the framing of the box cars are also threaded in this department.

An interesting home-made device is used for riveting the different parts on the iron end doors of the standard box car. It consists of the body of an old long-stroke air hammer attached to a frame, as shown in Fig. 37. Rivets are driven cold. As the treadle is pressed down the end of the hammer is brought down on the head of the rivet and is placed in operation.

Such material as is not brought directly into the car machine shop is stored outside at the most convenient point to the machine upon which it is to be finished. For instance, the rods which are used in the framing of the box cars, are stored along the north side of the machine shop, nearest to the bolt cutting machines. It is important in handling the large amount of this material to keep from getting the different size rods mixed and a very simple precaution has been taken to prevent this, as shown in Fig. 38. In addition to having the size plainly stencilled on the front of the bin the back of the bin is adjusted for the length of the rod which is to be placed in it, and as the rods are piled they are pushed back until they come in contact with the back. If the wrong length is put in a bin it immediately becomes noticeable. A clear passageway has been left between the back of the bin and the side of the building, and while this may seem a waste of space, yet it is possible to keep the surroundings much neater and cleaner than under other conditions.

Truck Shop.

One end of the wheel shop is used for finishing the wheels and axles and mounting them, as has been described. The remaining portion is devoted to the building and repairing of passenger car trucks and the building of freight car trucks. When the freight car shop is engaged in building box or refrigerator cars, only one track is used for building trucks, but when an order of flat cars is being built it is necessary to use two tracks. The truck gang, for an output of 28 standard 30-ton box cars per day, consists of seven men, including the foreman.

The mounted wheels are rolled on at one end of the track. The truck advances from one stage of construction to another, the material being piled at the proper place alongside the track, and each man having certain parts of the work which he must perform. The men are paid on a piece-work basis, and if one man slows up his associates see to it that he makes up for lost time, for the output of the entire gang will suffer. In like manner, if one man has difficulty in adjusting a part, the others see to it that he is given proper assistance. The gang works like a machine, except that intelligence is combined with energy, and if one part becomes clogged the energies of part of the gang are momentarily concentrated at that point until the difficulty is overcome.

The results are astonishing. Fifty-six trucks per day, or at the rate of eight for every man, including the foreman, or charge-hand, is doing a good day's work, and the men are not in an exhausted condition by any means when the whistle blows. It is the result of carefully planned and specialized work. It also requires the prompt delivery of material and that it be arranged and piled properly. It is the foreman's or charge-hand's duty to watch the delivery of material and oversee and assist the men.

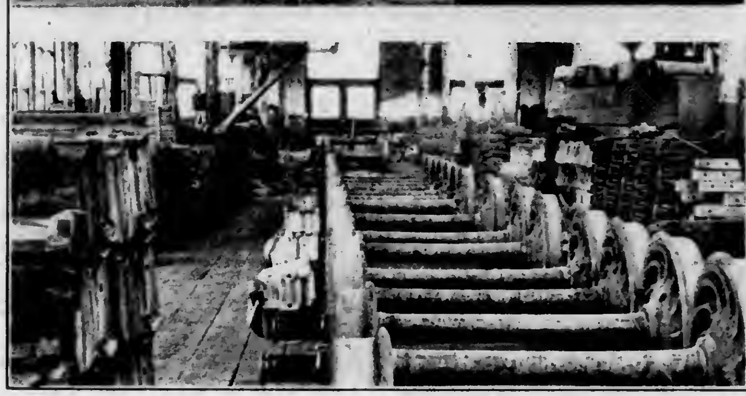


FIG. 38.—STORAGE BINS FOR RODS OUTSIDE OF MACHINE SHOP. STORAGE SHED ALONGSIDE THE BLACKSMITH SHOP IN THE REAR.
FIG. 39.—ERECTING TRACK IN TRUCK SHOP.

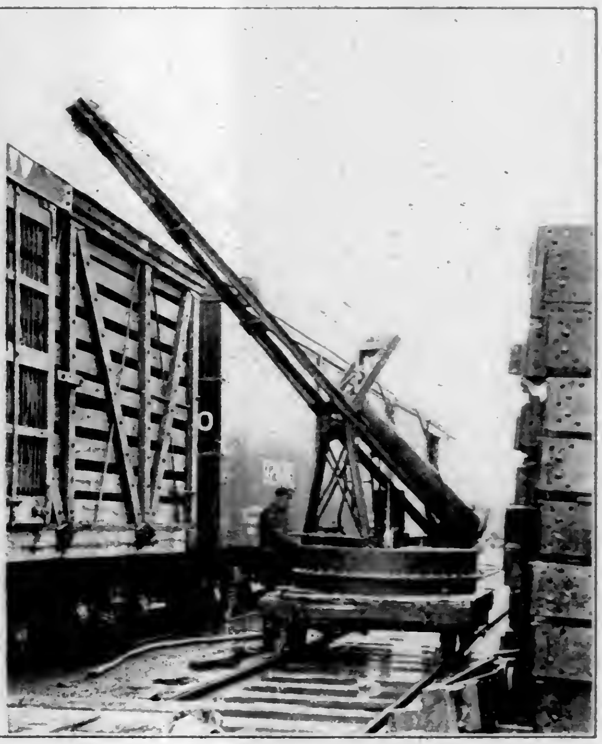


FIG. 44.—GARRY PNEUMATIC CRANE FOR UNLOADING BOLSTERS, ETC.

The accompanying photographs, showing the truck in different stages of erection, will assist in making the work of this department clear.

The wheels, after they are mounted, are placed on the track upon which the trucks are erected, as shown in Fig. 39. The journal boxes are fitted with dust guards and are placed on the journals by a helper, who devotes only a small portion of his time to this work. The journal boxes are stored in a large quantity alongside the track and additional storage room is provided just outside of the shop.

When the wheels in this condition are moved forward to a certain point two of the truck gang come back and fit the journal brasses and wedges in place. The wheels are then moved forward and the lower arch bar is placed on the boxes and the two column castings are placed on the sloping part of the bar. The sand plank (the brake hanger brackets are riveted to the sand plank in the smith shop) is then swung into place with a crane and the short bolts which connect it to the column castings are put in

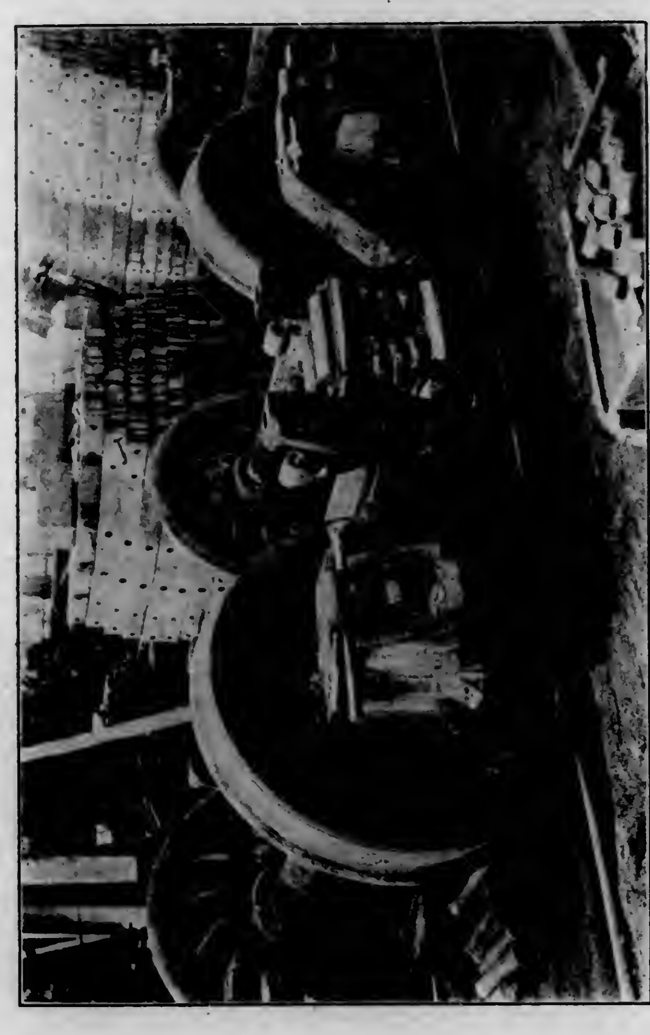


FIG. 40.—ONE OF THE EARLY STAGES OF ERECTION.

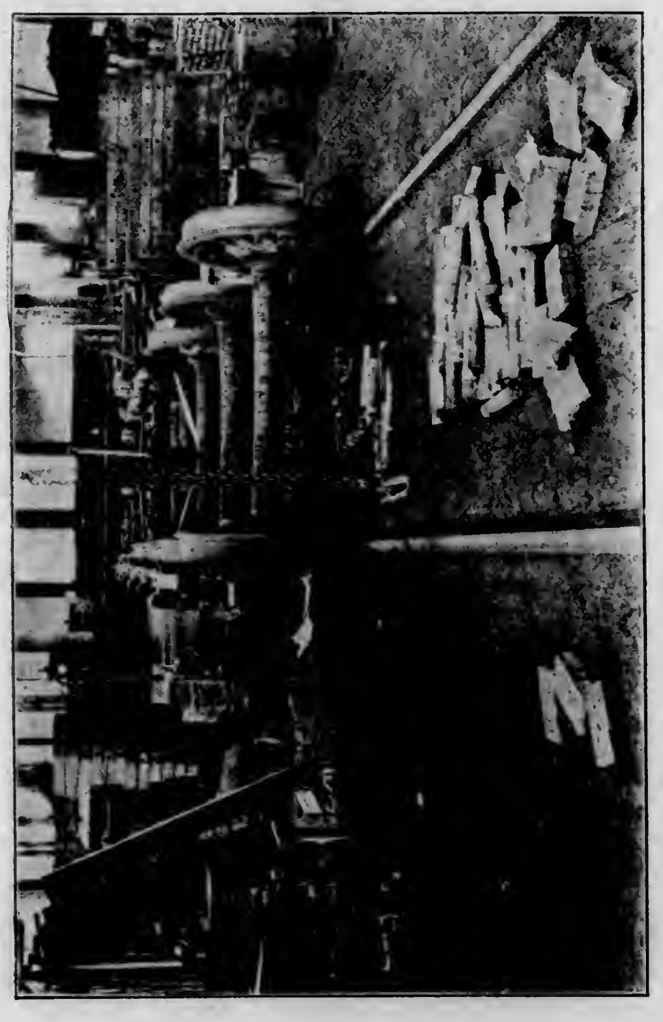


FIG. 41.—TRUCK ERECTING TRACK, SHOWING TRUCKS IN DIFFERENT STAGES OF ERECTION—ALSO ARRANGEMENT OF MATERIAL ALONGSIDE AND IN THE MIDDLE OF THE TRACK.

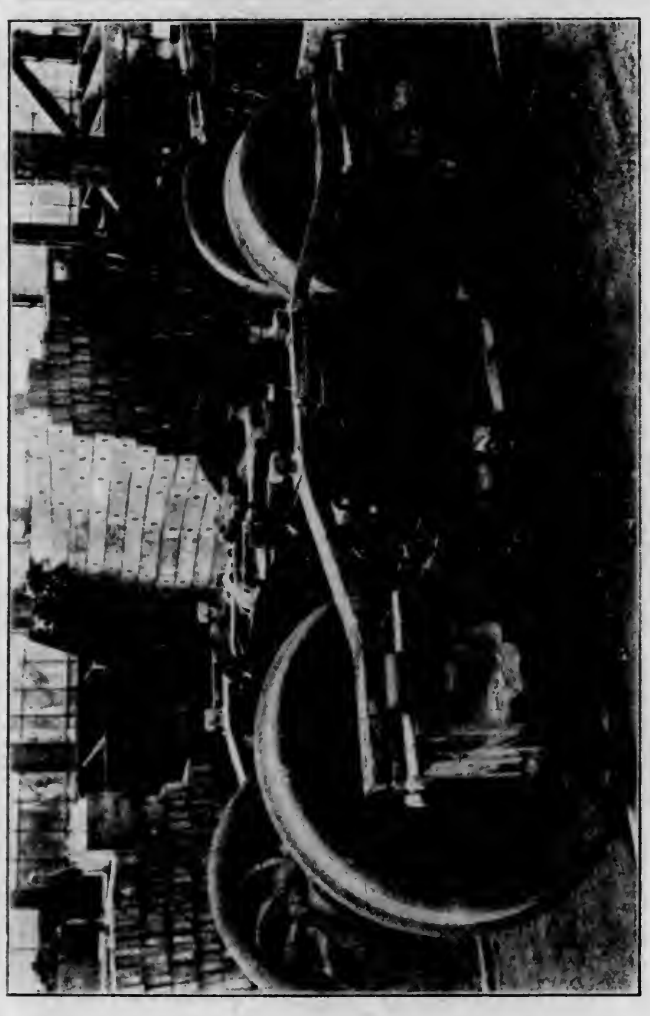


FIG. 42.—AN ADVANCED STAGE OF ERECTION.

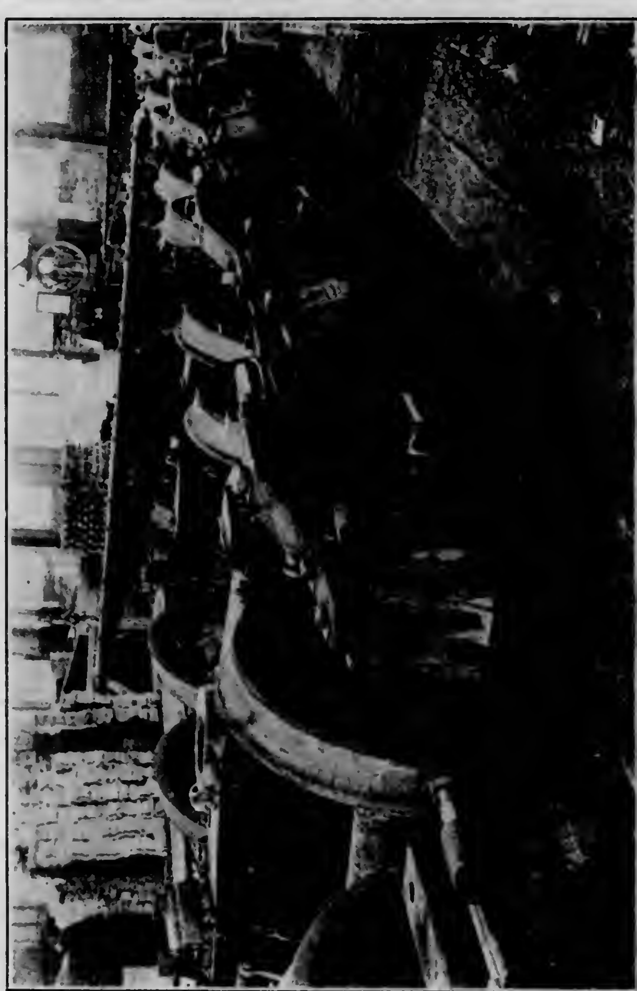


FIG. 43.—READY FOR THE TIE BARS AND THE FINISHING TOUCHES.

FIG. 45.—FIVE TON GRAFTON CRANE IN THE LUMBER YARD.

place, but the nuts are not drawn up tight. The spring seat, springs, spring cap and the Barber rollers, are put in place and the journal bolts are laid on top of the box alongside the arch bar. The truck in this condition is shown in Fig. 40. Another view of the same stage, but looking down the shop and showing the various stages of erection and the material piled along both sides and in the middle of the track, is shown in Fig. 41.

The truck is moved forward and the truck bolster is dropped into place by a crane and the top arch bars are placed in position. The column bolts are then driven in. The work described thus far, excepting for the placing in position of the truck bolster, has all been done by two men. The partially erected truck has been moved forward possibly a couple of times. While the first two men have been driving in the column bolts a third man has been engaged in hanging the brake beams. This man also tightens up the inside bolts which connect the column castings and the spring plank. When the work has progressed thus far the truck is again moved forward and two other men drive in the journal box bolts, while the sixth man is engaged in putting in the brake levers. This sixth man is the one who puts the truck bolsters in place with the aid of a crane and he also puts the body bolster in place after the truck has been completed. It is the duty of the fourth and fifth men to put the bottom tie bar into place and to put the nuts on and draw up the column and journal box bolts. As may be seen in Fig. 43, a pit is provided alongside the track for this last operation, so that the men may perform it conveniently.

One can hardly realize the rapidity with which a truck is erected without actually seeing it done. In watching the gang it was noticed that there was practically no talking among the men and questioning developed these facts. The gang boss was a Scotch-Irishman, who could talk no French; two of the men were Jews; two were French, one of them could not talk English; one was a Russian and could speak only his own language; the other member was an Italian and could speak English and some French. As the men were working piece-work it is not surprising that there was not much talking, but the fact that such a mixture of men could do such efficient work speaks well for the system of organization and of specialization. After the trucks are completed they are either pushed out of the shop and stored on the other side of the midway or are taken directly to the freight car building shop.

The Simplex truck and body bolsters, the springs, brake beams and journal boxes are unloaded from the cars and stored just outside the shop. The bolsters are unloaded by the 2,000-lb. Garry crane illustrated in Fig. 44. The end of the cable is fastened to the bolster inside the car, a piece of wood being placed between the cable and the side or top of the door, so that in drawing out the bolster the car will not be injured. These cranes were furnished by the Garry Iron & Steel Company, who have since disposed of this part of their business to the Cleveland City Forge & Iron Company of Cleveland. Clamps are provided for holding the crane to the rail when in operation. The revolving bed rests on a row of 196 1½ in. steel balls. The load is lifted by the air cylinder, and revolved by another air cylinder, placed within the revolving bed. The swinging movement is controlled by an air brake. The crane is portable but not self-propelling. It has a lift of 12 ft. 6 in. and a reach of 12 ft.

Lumber Yard.

The lumber yard covers about 40 acres and is laid out with 25 tracks. The store department inspects, culls and tallys all lumber as it is received, and sees that it is properly piled. An idea of the extent of this work may be gained from the following extract taken from a paper presented by Mr. J. H. Callaghan, the general storekeeper, before the Canadian Railway Club in January, 1906. The figures are, of course, still larger at the present time.

"For the ten months ending October 31, 1905, there were no less than 2,350 cars of lumber unloaded and piled, a total of 28,188,000 feet, or an average of 113,000 feet daily. The quantity delivered to shops and shipped on the line for the same period amounted to about 4,000,000 feet in excess of these figures. The stock carried for all purposes during the present year has varied from eight to thirteen million feet, board measure, of which quantity one and a half millions are carried for the purpose of supplying outside points and repair work, the balance for new equipment orders. The woods carried in this stock range from the ordinary spruce, pine, birch, and oak used for freight car construction, to the rarest imported woods used in finishing the passenger rolling stock."

The lumber is delivered to the planing mill and dry-kiln on four-wheel lorry trucks. The sills are loaded by the Grafton & Co. (Bedford, England,) 5-ton crane, shown in Fig. 45. When four or five of the lorry cars have been loaded they are coupled together and pulled to their destination by the Grafton crane. This crane is capable of lifting 5 tons at 15 ft., 3 tons at 21 ft., and 2 tons at 27 ft. radius, traveling with any of these loads when free and in any position. It has the following motions: Hoisting, lowering, either by the engines or by brake; slewing in either direction, independent of the sense of rotation of the engines; derricking and traveling. The driver at all times has a clear and

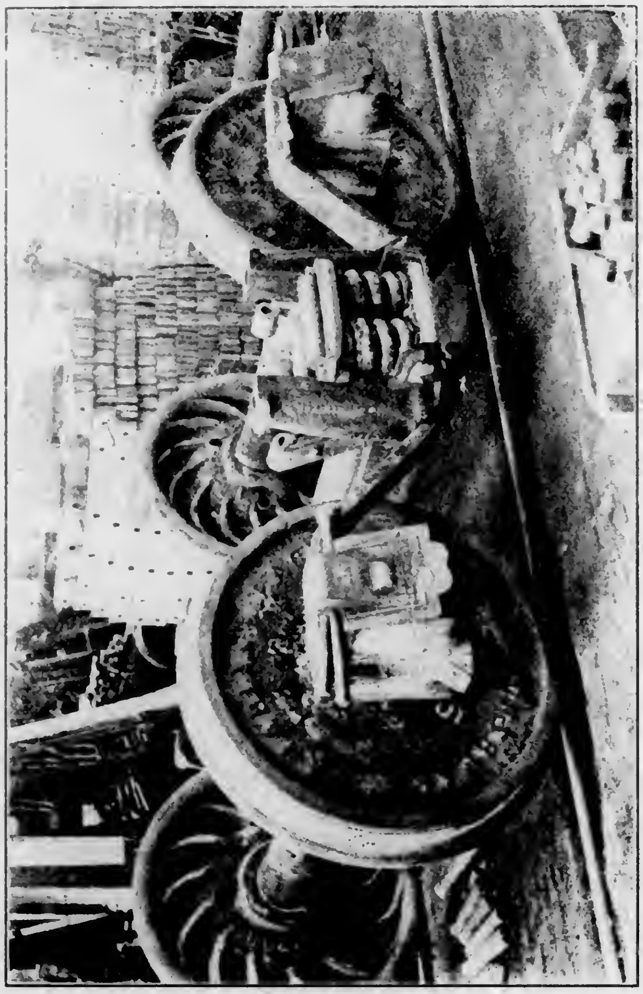


FIG. 40.—ONE OF THE EARLY STAGES OF ERECTION.

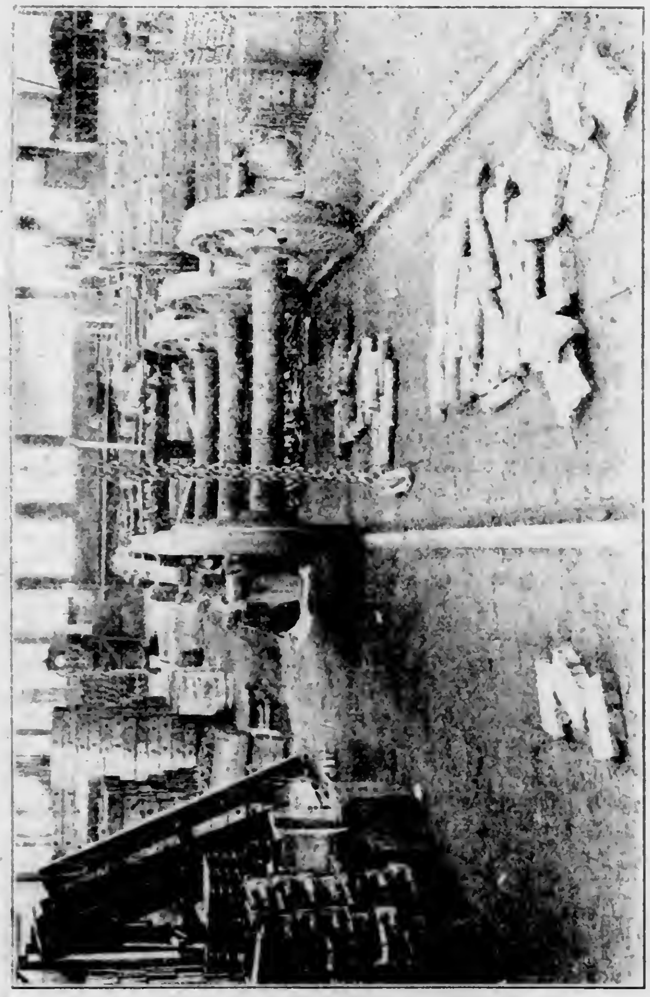


FIG. 41. TRUCK ERECTING TRACK, SHOWING TRUCKS IN DIFFERENT STAGES OF ERECTION. ALSO ARRANGEMENT OF MATERIAL ALONGSIDE AND IN THE MIDDLE OF THE TRACK.

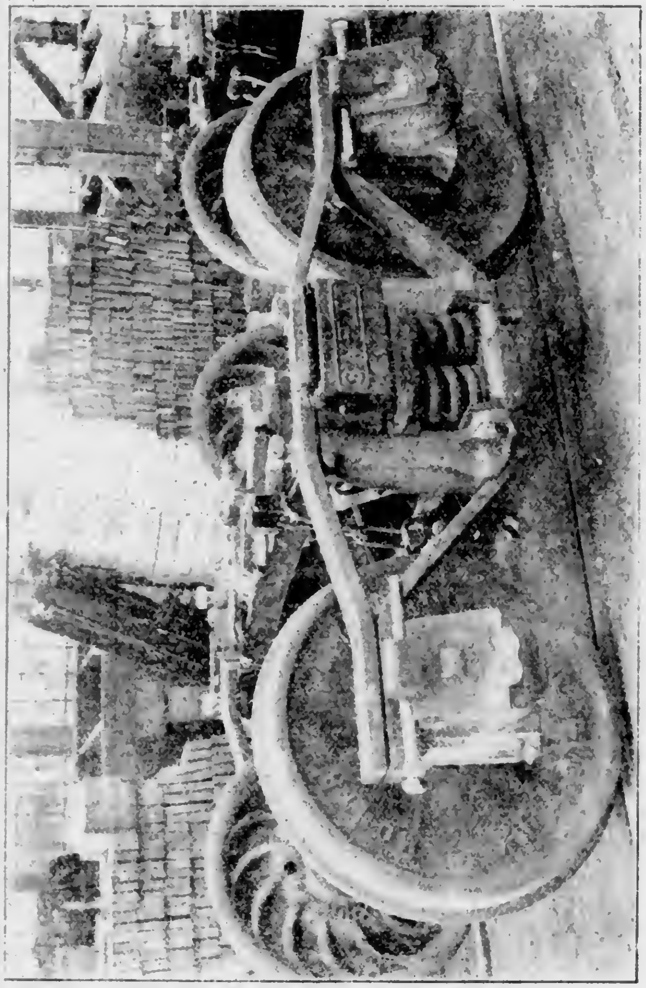


FIG. 42. AN ADVANCED STAGE OF ERECTION.

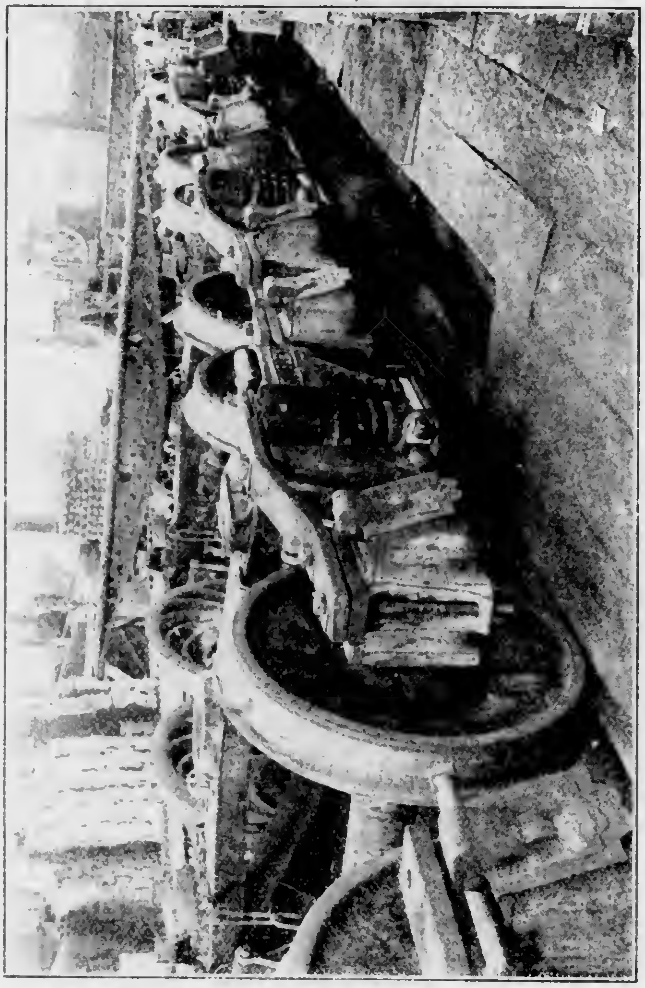


FIG. 43.—READY FOR THE TIE BARS AND THE FINISHING TOUCHES.

FIG. 45.—FIVE-TON GRAFTON CRANE IN THE LUMBER YARD.

place, but the nuts are not drawn up tight. The spring seat, springs, spring cap and the Barber rollers, are put in place and the journal bolts are laid on top of the box alongside the arch bar. The truck in this condition is shown in Fig. 40. Another view of the same stage, but looking down the shop and showing the various stages of erection and the material piled along both sides and in the middle of the track, is shown in Fig. 41.

The truck is moved forward and the truck bolster is dropped into place by a crane and the top arch bars are placed in position. The column bolts are then driven in. The work described thus far, excepting for the placing in position of the truck bolster, has all been done by two men. The partially erected truck has been moved forward possibly a couple of times. While the first two men have been driving in the column bolts a third man has been engaged in hanging the brake beams. This man also tightens up the inside bolts which connect the column castings and the spring plank. When the work has progressed thus far the truck is again moved forward and two other men drive in the journal box bolts, while the sixth man is engaged in putting in the brake levers. This sixth man is the one who puts the truck bolsters in place with the aid of a crane and he also puts the body bolster in place after the truck has been completed. It is the duty of the fourth and fifth men to put the bottom tie bar into place and to put the nuts on and draw up the column and journal box bolts. As may be seen in Fig. 43, a pit is provided alongside the track for this last operation, so that the men may perform it conveniently.

One can hardly realize the rapidity with which a truck is erected without actually seeing it done. In watching the gang it was noticed that there was practically no talking among the men and questioning developed these facts. The gang boss was a Scotch-Irishman, who could talk no French; two of the men were Jews; two were French, one of them could not talk English; one was a Russian and could speak only his own language; the other member was an Italian and could speak English and some French. As the men were working piece-work it is not surprising that there was not much talking, but the fact that such a mixture of men could do such efficient work speaks well for the system of organization and of specialization. After the trucks are completed they are either pushed out of the shop and stored on the other side of the midway or are taken directly to the freight car building shop.

The Simplex truck and body bolsters, the springs, brake beams and journal boxes are unloaded from the cars and stored just outside the shop. The bolsters are unloaded by the 2,000-lb. Garry crane illustrated in Fig. 44. The end of the cable is fastened to the bolster inside the car, a piece of wood being placed between the cable and the side or top of the door, so that in drawing out the bolster the car will not be injured. These cranes were furnished by the Garry Iron & Steel Company, who have since disposed of this part of their business to the Cleveland City Forge & Iron Company of Cleveland. Clamps are provided for holding the crane to the rail when in operation. The revolving bed rests on a row of 100 1 [illegible] in. steel balls. The load is lifted by the air cylinder, and revolved by another air cylinder, placed within the revolving bed. The swinging movement is controlled by an air brake. The crane is portable but not self-propelling. It has a lift of 12 ft. 6 in. and a reach of 12 ft.

Lumber Yard.

The lumber yard covers about 40 acres and is laid out with 25 tracks. The store department inspects, culls and tallys all lumber as it is received, and sees that it is properly piled. An idea of the extent of this work may be gained from the following extract taken from a paper presented by Mr. J. H. Callaghan, the general storekeeper, before the Canadian Railway Club in January, 1906. The figures are, of course, still larger at the present time.

"For the ten months ending October 31, 1905, there were no less than 2,350 cars of lumber unloaded and piled, a total of 28,188,000 feet, or an average of 113,000 feet daily. The quantity delivered to shops and shipped on the line for the same period amounted to about 4,000,000 feet in excess of these figures. The stock carried for all purposes during the present year has varied from eight to thirteen million feet, board measure, of which quantity one and a half millions are carried for the purpose of supplying outside points and repair work, the balance for new equipment orders. The woods carried in this stock range from the ordinary spruce, pine, birch, and oak used for freight car construction, to the rarest imported woods used in finishing the passenger rolling stock."

The lumber is delivered to the planing mill and dry-kiln on four-wheel lorry trucks. The sills are loaded by the Grafton & Co. (Bedford, England.) 5-ton crane, shown in Fig. 45. When four or five of the lorry cars have been loaded they are coupled together and pulled to their destination by the Grafton crane. This crane is capable of lifting 5 tons at 15 ft., 3 tons at 21 ft., and 2 tons at 27 ft. radius, traveling with any of these loads when free and in any position. It has the following motions: Hoisting, lowering, either by the engines or by brake; slewing in either direction, independent of the sense of rotation of the engines; derricking and traveling. The driver at all times has a clear and

FIG. 46.—LORRY CARS LOADED WITH LUMBER READY TO BE TAKEN INTO THE PLANING MILL.

FIG. 50.—THE FINISHED SILLS READY TO BE TRANSFERRED TO THE FREIGHT CAR SHOP.

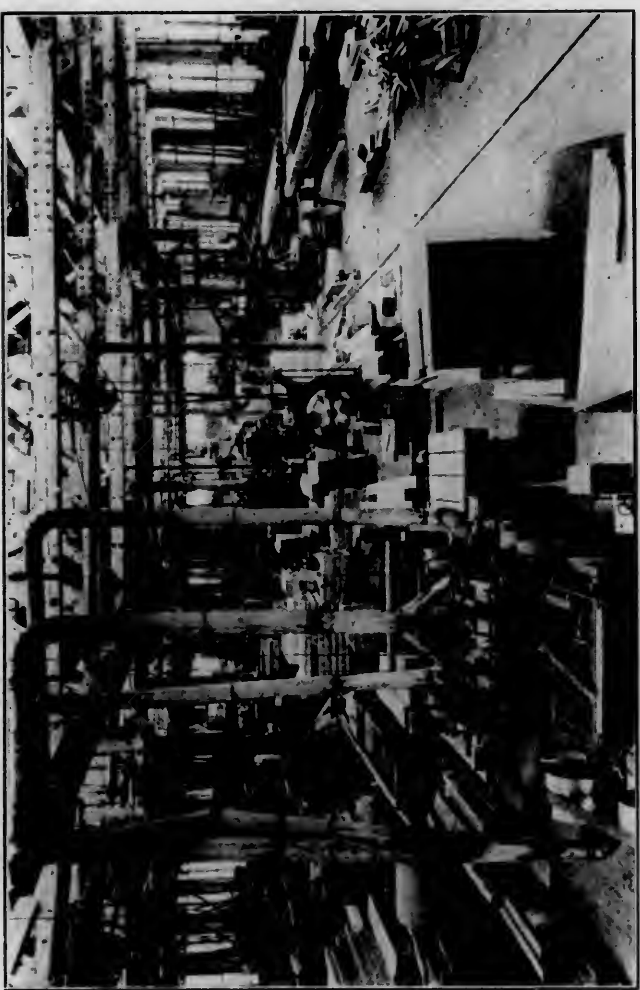


FIG. 51.—LOOKING DOWN THE MIDDLE OF THE PLANING MILL FROM A STAIRWAY AT THE EAST END.

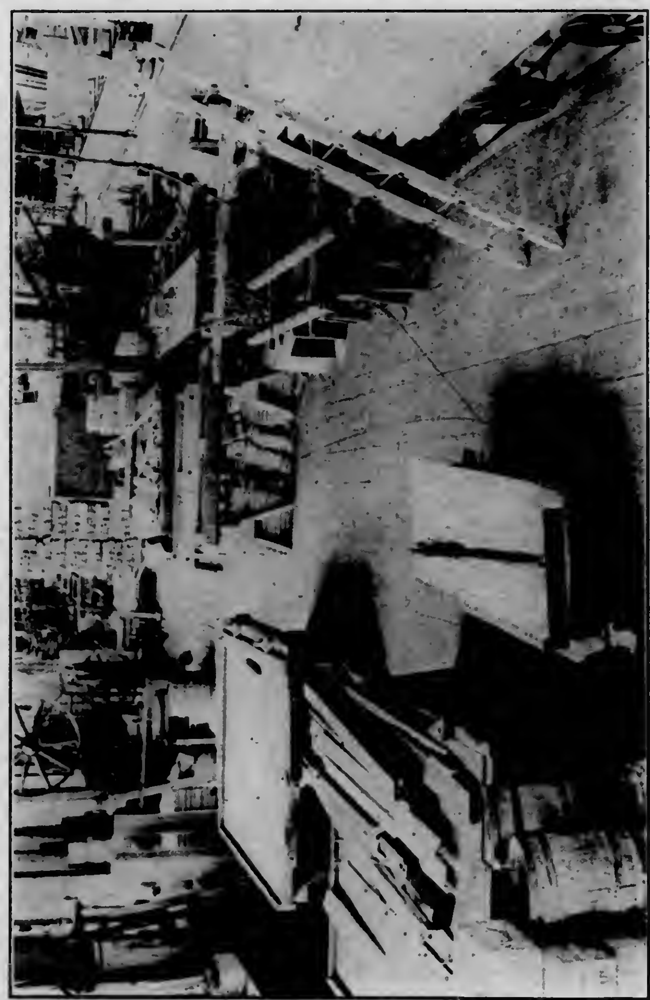


FIG. 52.—BOX CAR SIDE DOOR AND LADDER DEPARTMENT IN THE PLANING MILL.

FIG. 48.—END OF THE PLANING MILL, LOOKING FROM THE FREIGHT CAR SHOP.

uninterrupted view of his work. A safe load indicator shows the radius of the jib and the corresponding safe working load.

Ordinarily the crane pulls about 4 or 5 loads, but the writer saw it handling 7 loads as follows: Three cars of sills (90); 2 cars end plates (100); 1 car needle beams (50); and 1 car purlins (120). These were taken to the north end of the planing mill (Fig. 46), and by means of the transfer table were placed where they could be run into the shop when needed.

Dry Kiln.

The dry kiln of the freight car department (Fig. 47) is located near the west end of the planing mill, is divided into three compartments, each 19 x 85 ft. and has a capacity for 148,000 ft. of lumber. The kiln is equipped with the Morton system, furnished by the A. H. Andrews Company of Chicago. The side walls are of brick, the division walls of timber and the roof is of wood with gravel covering. The ends of the kiln are covered with canvas curtains which may be rolled up. Special attention is directed to the location of the kiln. The machines in the mill for finishing the lumber which passes through the kiln, are all located near the entrance from the kiln.

Planing Mill.*

The planing mill is directly across the midway from the freight car erecting shop, with sufficient space between it and the midway to provide for the temporary storage of finished material. This end of the mill is shown in Fig. 48. There is a transfer table, shown also in Fig. 1, just behind the trucks in the foreground of this view. For lack of space a plan of the mill is not reproduced. The one on page 117 of the April, 1905, issue is practically correct, as comparatively few changes have been made since that time.

The mill is divided into two parts with two foremen, one representing the freight car department and the other the passenger car department. It has two longitudinal tracks extending through it, dividing it into three parts. The part on the north side and the greater portion of the middle part are used by the freight car department. The sills enter at the northeastern end of the mill and are passed directly from the truck to the planer. A view looking down this part of the shop is shown in Fig. 49. The cross-cut saw at the right is used for cutting the sills to length. They are then laid off for drilling and tenoning and are passed down the shop to the end tenoning machine, five spindle vertical boring machine and gaining machine. Fig. 50 is a view looking toward the northeast from the point where the sills are in a finished condition and ready to be loaded on a truck with the air hoist and be pushed through to the freight car shop. The middle portion of the mill at the east end is used principally for finishing the various parts of the freight car framing and Fig. 51 is a view looking down this part of the shop from a stairway at the east end.

Just west of that part of the north side of shop, where the sills are finished, is a small department for building grain doors and side and end ladders, as shown in Fig. 52. A government regulation requires the addition of duplicate ladders and steps to all the freight car equipment in use. Twenty thousand of these ladders were built during the past year. They are painted by dipping them in a vat just west of the mill.

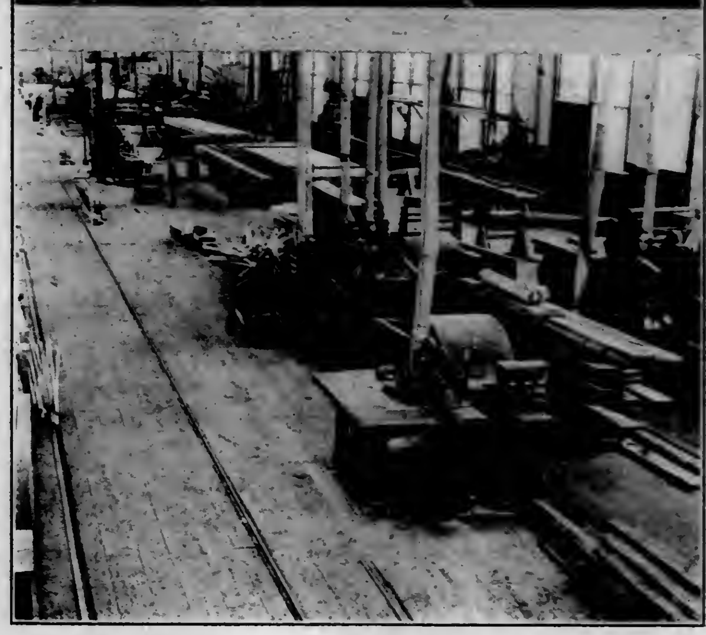


FIG. 47.—FREIGHT CAR DEPARTMENT DRY KILN.
FIG. 49.—SILL DEPARTMENT OF THE PLANING MILL.

* For a description of the building see page 37 of the February, 1905, issue.

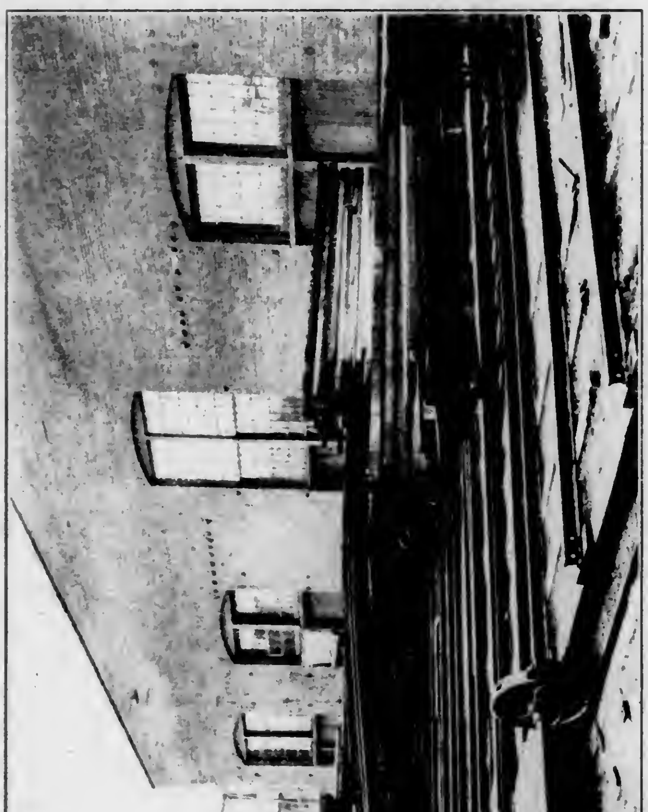


FIG. 46.—LORRY CARS LOADED WITH LUMBER READY TO BE TAKEN INTO THE PLANING MILL.

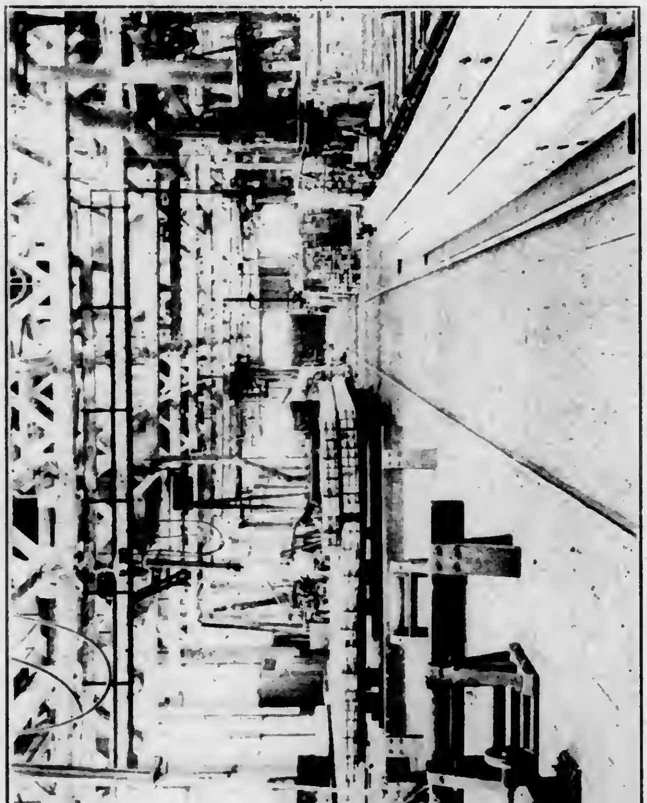


FIG. 50.—THE FINISHED SILLS READY TO BE TRANSFERRED TO THE FREIGHT CAR SHOP.

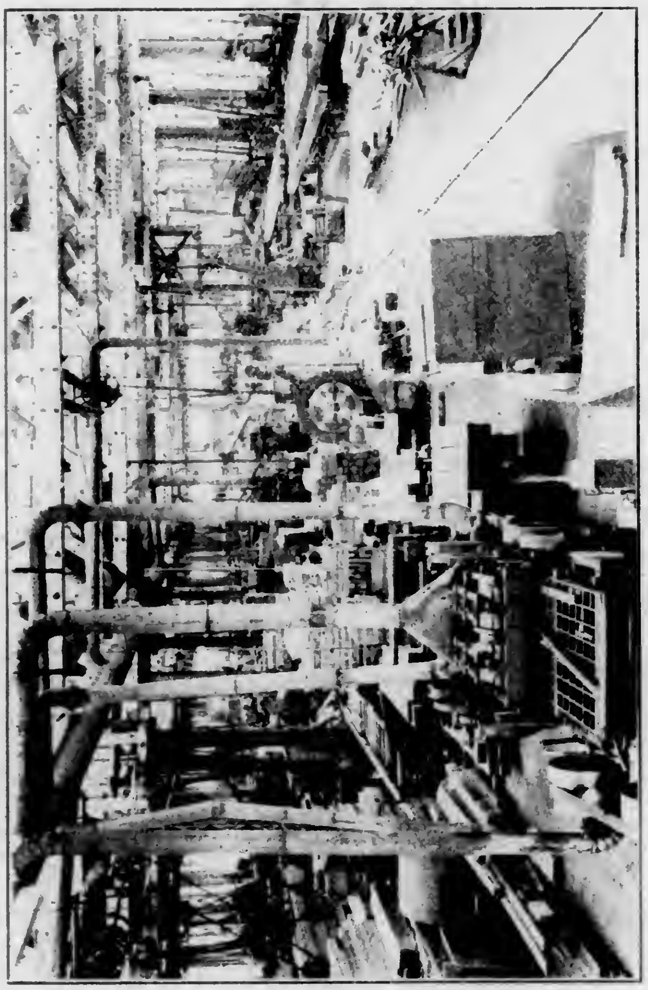


FIG. 51.—LOOKING DOWN THE MIDDLE OF THE PLANING MILL FROM A STAIRWAY AT THE EAST END.

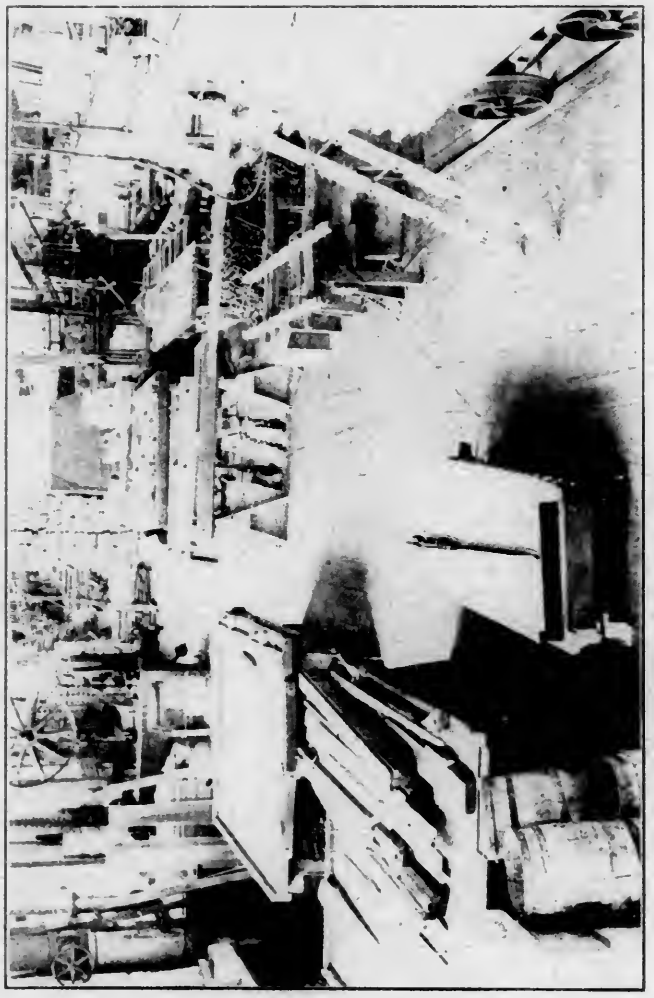


FIG. 52.—BOX CAR SIDE DOOR AND LADDER DEPARTMENT IN THE PLANING MILL.

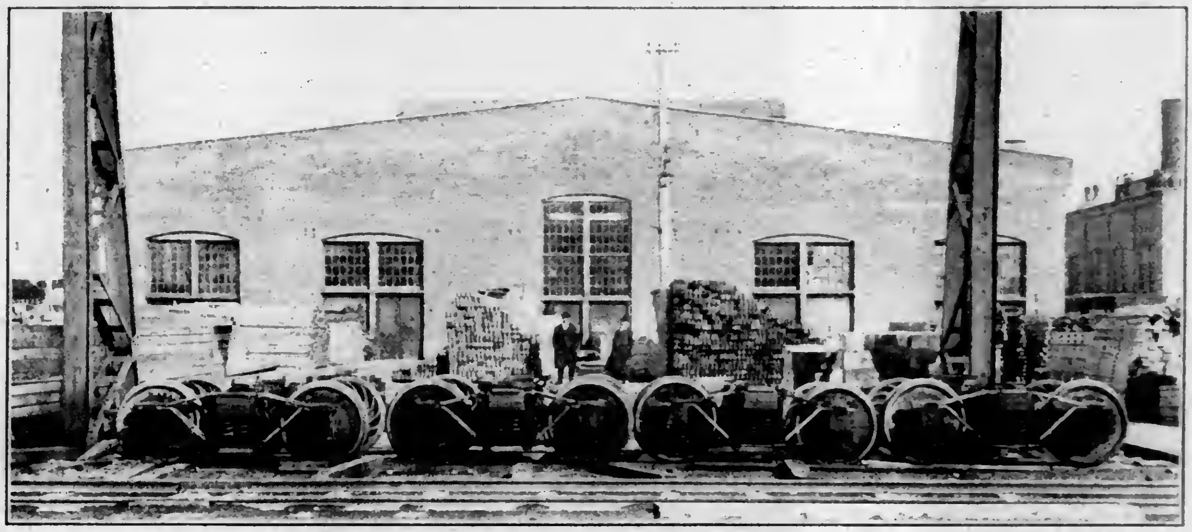


FIG. 48.—END OF THE PLANING MILL, LOOKING FROM THE FREIGHT CAR SHOP.

uninterrupted view of his work. A safe load indicator shows the radius of the jib and the corresponding safe working load.

Ordinarily the crane pulls about 4 or 5 loads, but the writer saw it handling 7 loads as follows: Three cars of sills (90); 2 cars end plates (100); 1 car needle beams (50); and 1 car purlins (120). These were taken to the north end of the planing mill (Fig. 46), and by means of the transfer table were placed where they could be run into the shop when needed.

Dry Kiln.

The dry kiln of the freight car department (Fig. 47) is located near the west end of the planing mill, is divided into three compartments, each 19 x 85 ft. and has a capacity for 148,000 ft. of lumber. The kiln is equipped with the Morton system, furnished by the A. H. Andrews Company of Chicago. The side walls are of brick, the division walls of timber and the roof is of wood with gravel covering. The ends of the kiln are covered with canvas curtains which may be rolled up. Special attention is directed to the location of the kiln. The machines in the mill, for finishing the lumber which passes through the kiln, are all located near the entrance from the kiln.

Planing Mill.*

The planing mill is directly across the midway from the freight car erecting shop, with sufficient space between it and the midway to provide for the temporary storage of finished material. This end of the mill is shown in Fig. 48. There is a transfer table, shown also in Fig. 1, just behind the trucks in the foreground of this view. For lack of space a plan of the mill is not reproduced. The one on page 117 of the April, 1905, issue is practically correct, as comparatively few changes have been made since that time.

The mill is divided into two parts with two foremen, one representing the freight car department and the other the passenger car department. It has two longitudinal tracks extending through it, dividing it into three parts. The part on the north side and the greater portion of the middle part are used by the freight car department. The sills enter at the northeastern end of the mill and are passed directly from the truck to the planer. A view looking down this part of the shop is shown in Fig. 49. The cross-cut saw at the right is used for cutting the sills to length. They are then laid off for drilling and tenoning and are passed down the shop to the end tenoning machine, five spindle vertical boring machine and gaining machine. Fig. 50 is a view looking toward the northeast from the point where the sills are in a finished condition and ready to be loaded on a truck with the air hoist and be pushed through to the freight car shop. The middle portion of the mill at the east end is used principally for finishing the various parts of the freight car framing and Fig. 51 is a view looking down this part of the shop from a stairway at the east end.

Just west of that part of the north side of shop, where the sills are finished, is a small department for building grain doors and side and end ladders, as shown in Fig. 52. A government regulation requires the addition of duplicate ladders and steps to all the freight car equipment in use. Twenty thousand of these ladders were built during the past year. They are painted by dipping them in a vat just west of the mill.

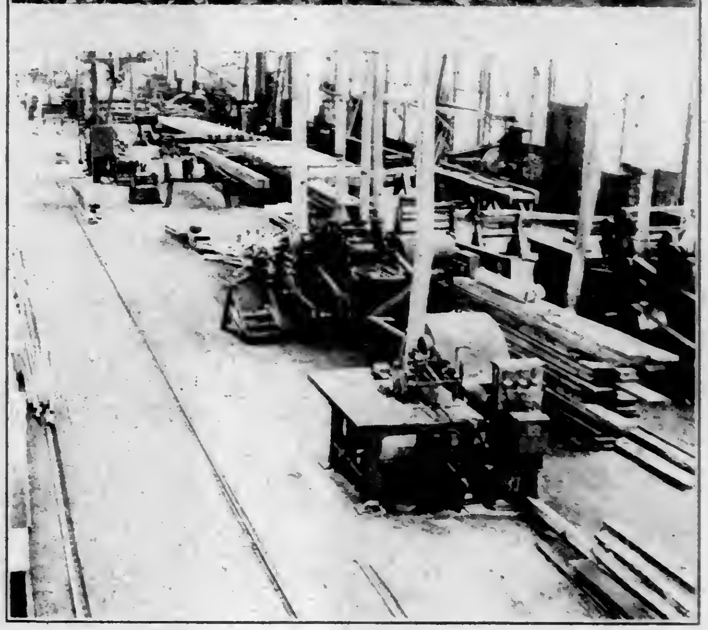


FIG. 47.—FREIGHT CAR DEPARTMENT DRY KILN.
FIG. 49.—SILL DEPARTMENT OF THE PLANING MILL.

* For a description of the building see page 37 of the February, 1905, issue.

FIG. 53.—BERLIN PLANER AND CUT-OFF SAW AT WEST END OF MILL.

FIG. 54.—BOLT BINS AT EAST END OF FREIGHT CAR SHOP.

FIG. 55.—LOOKING DOWN ONE OF THE MATERIAL TRACKS.

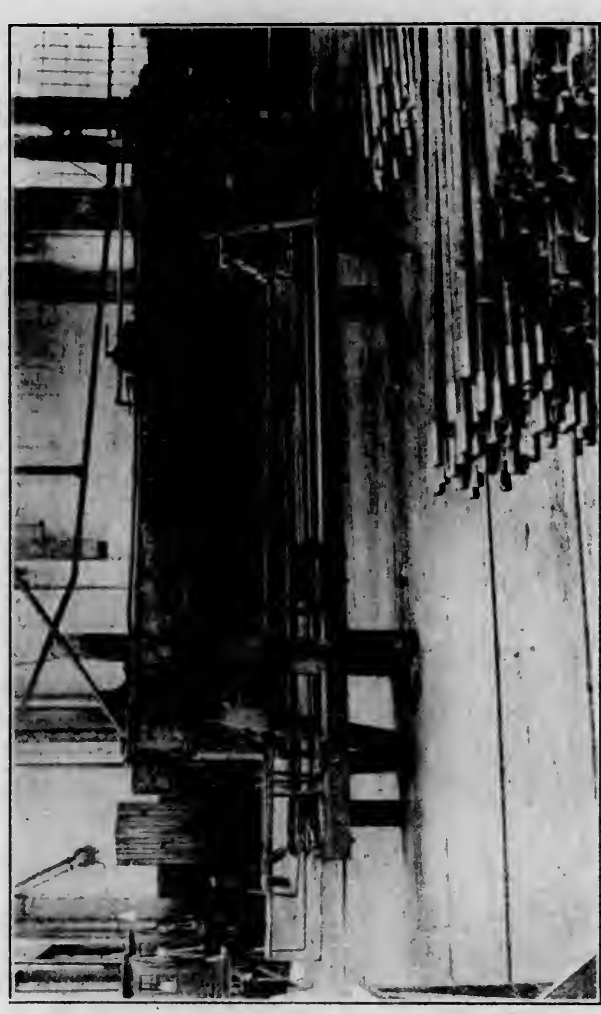


FIG. 56.—DEVICE FOR BENDING TRUSS ROADS COMPLETE AT ONE OPERATION.

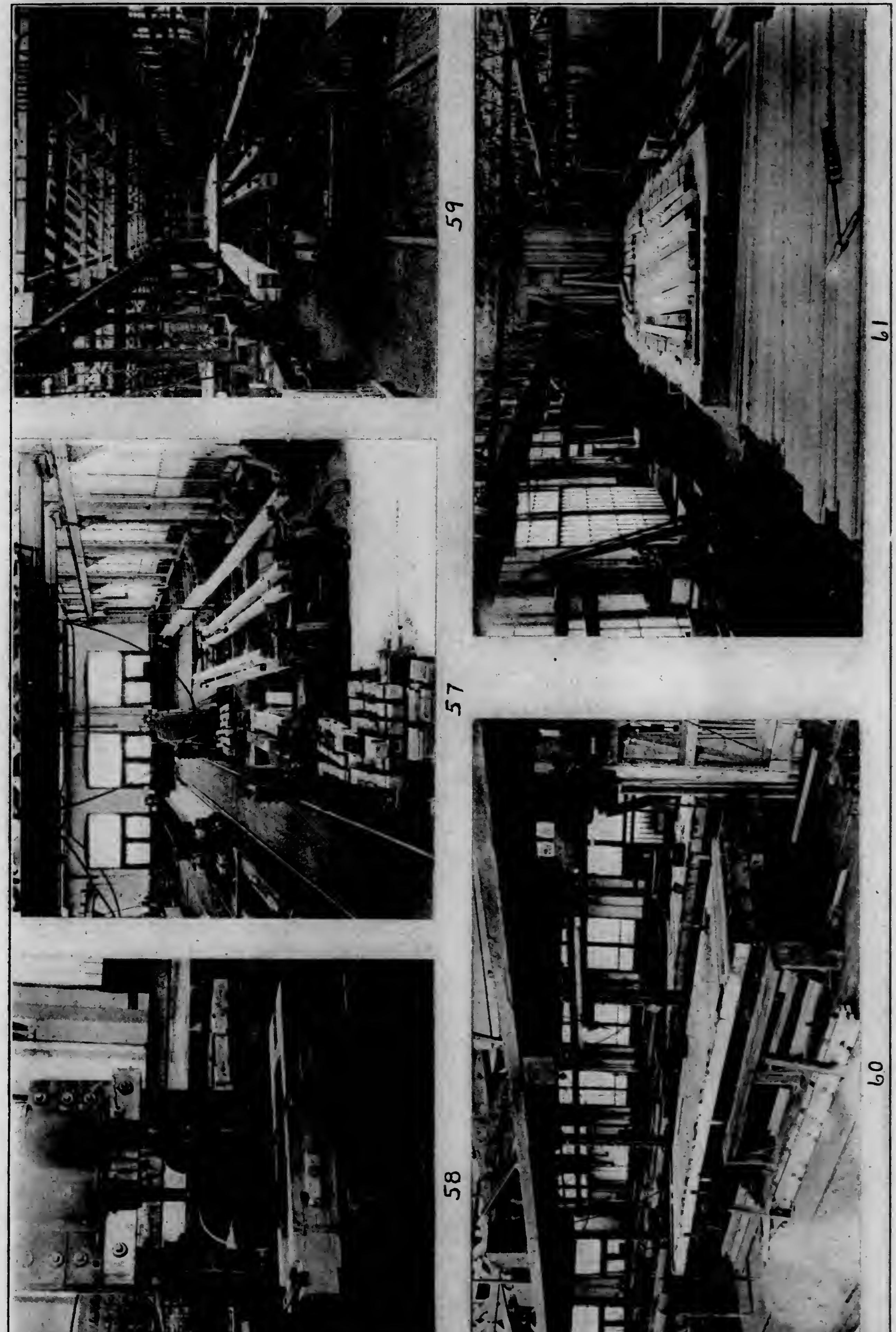


FIG. 57.—A CAR IN THE SECOND STAGE OF ERECTION. DRAFT RIGGING ASSEMBLING DEVICES SHOWN ALONGSIDE THE CAR AT EACH END. BOLT BINS IN THE REAR. FIG. 58.—DEVICE FOR PUTTING SPRINGS AND FOLLOWERS IN DRAFT SILLS. FIG. 59.—LOOKING DOWN ONE OF THE ERECTING TRACKS. A CAR IN THE SECOND STAGE OF ERECTION IN THE FOREGROUND. FIG. 60.—THE THIRD STAGE—LAYING THE FLOOR. FIG. 61.—THE FOURTH STAGE—THE ROOF FRAME WILL NEXT BE BUILT.

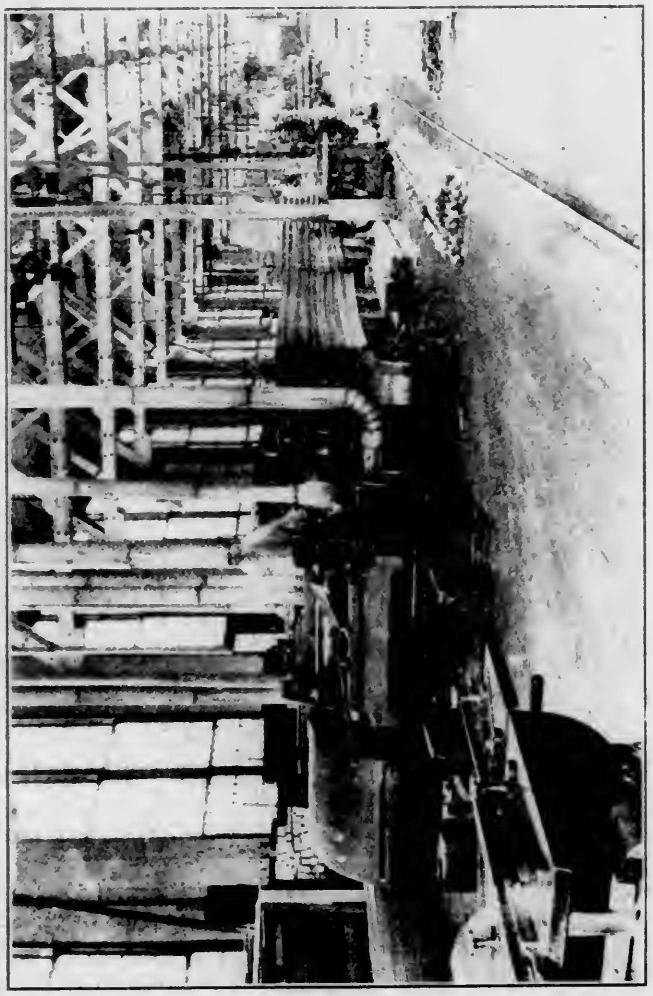


FIG. 53.—BERLIN PLANER AND CUT-OFF SAW AT WEST END OF MILL.

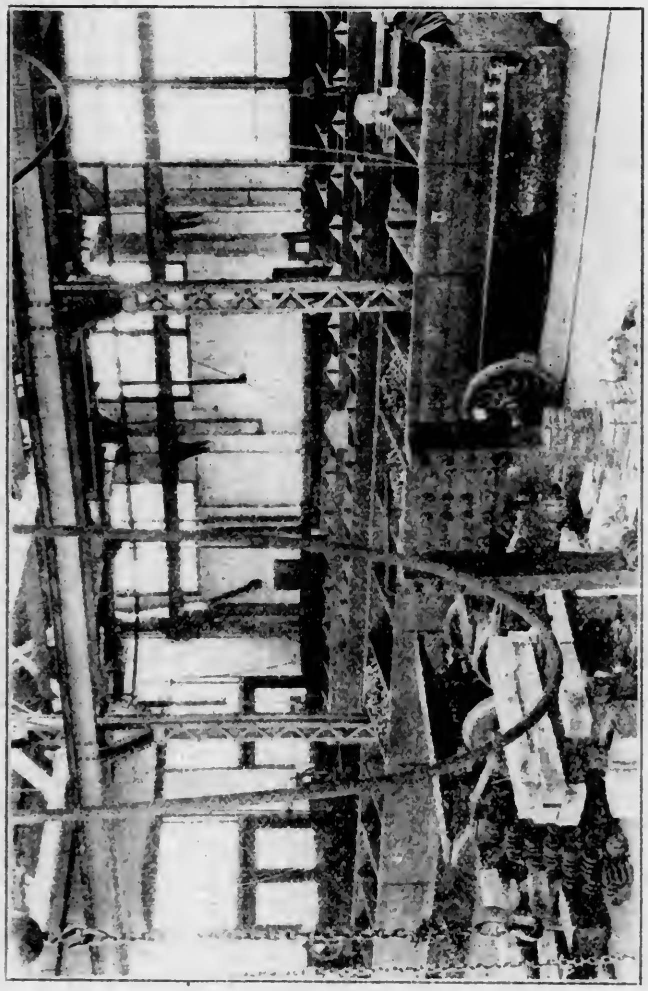


FIG. 54.—BOLT BINS AT EAST END OF FREIGHT CAR SHOP.

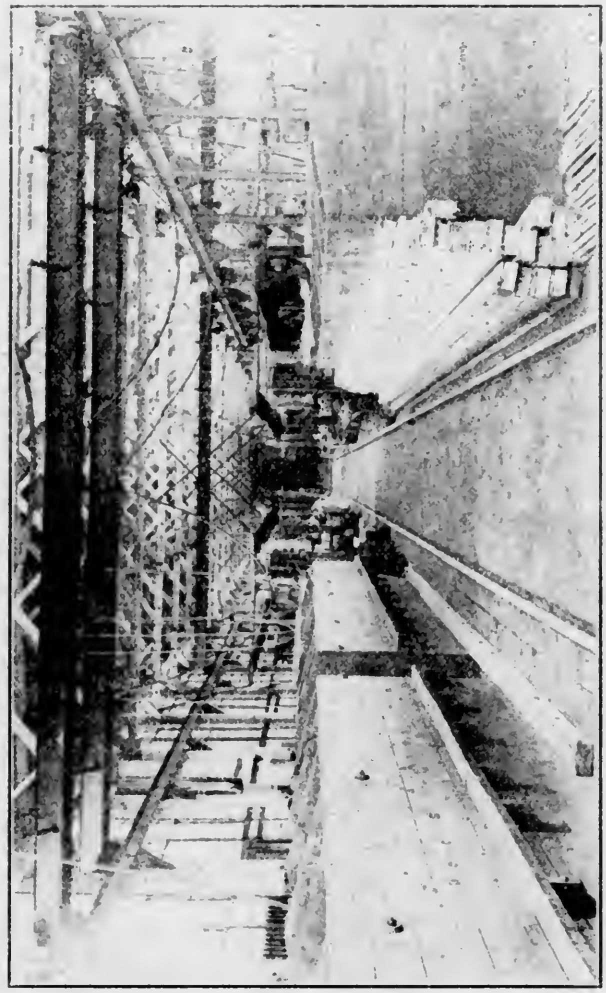


FIG. 55.—LOOKING DOWN ONE OF THE MATERIAL TRACKS.

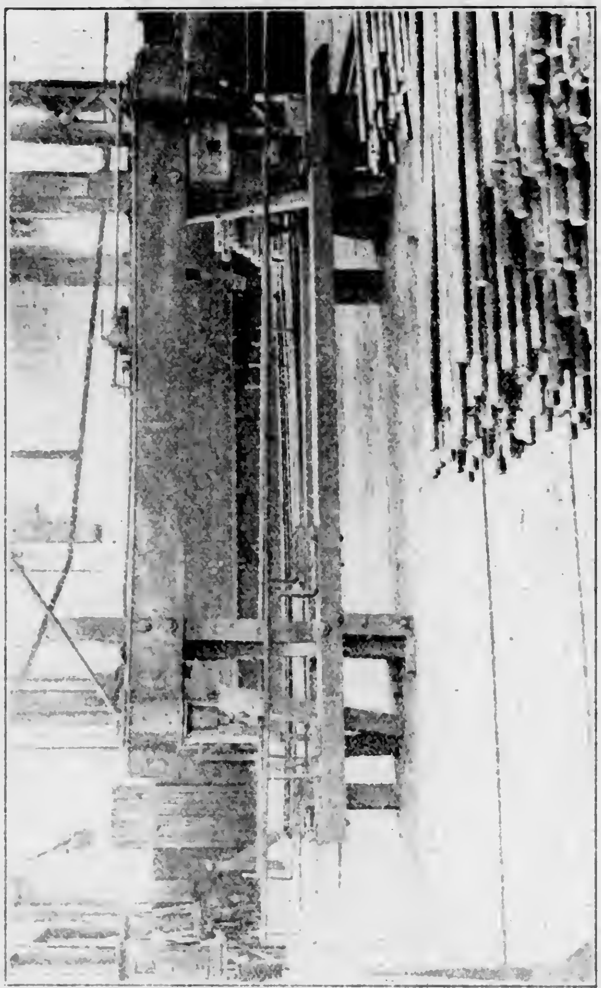
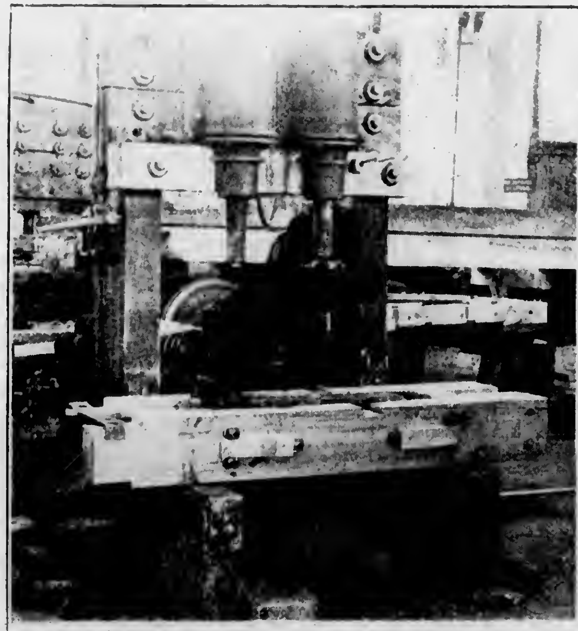
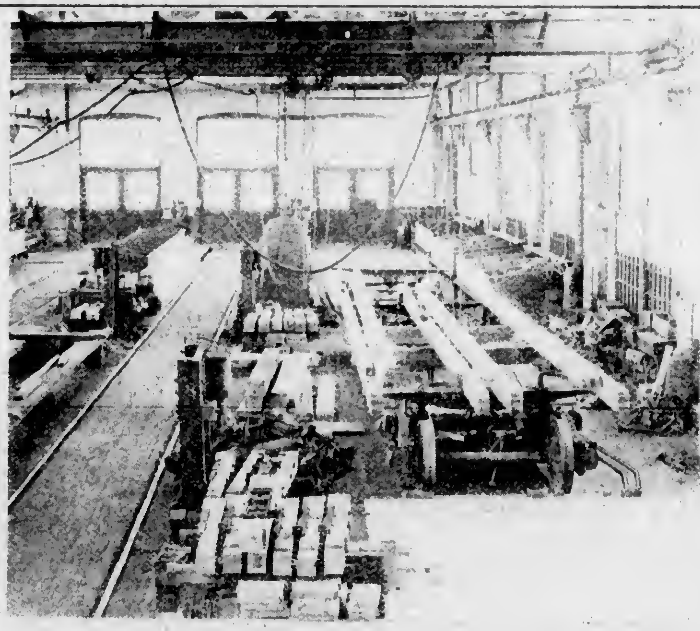


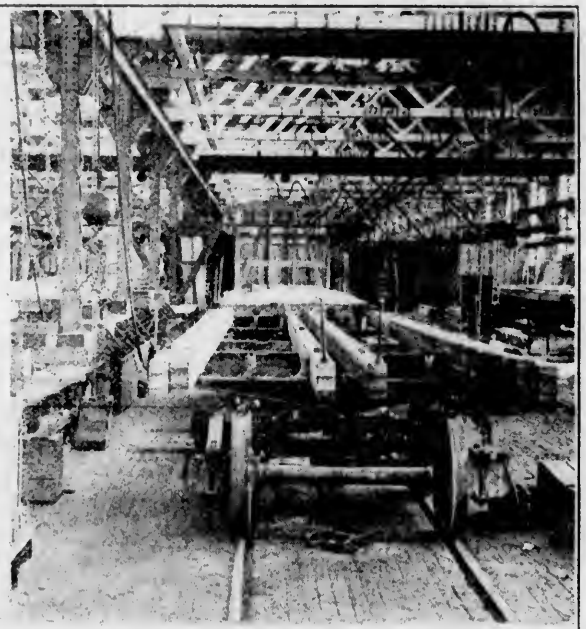
FIG. 56.—DEVICE FOR BENDING TRUSS RODS COMPLETE AT ONE OPERATION.



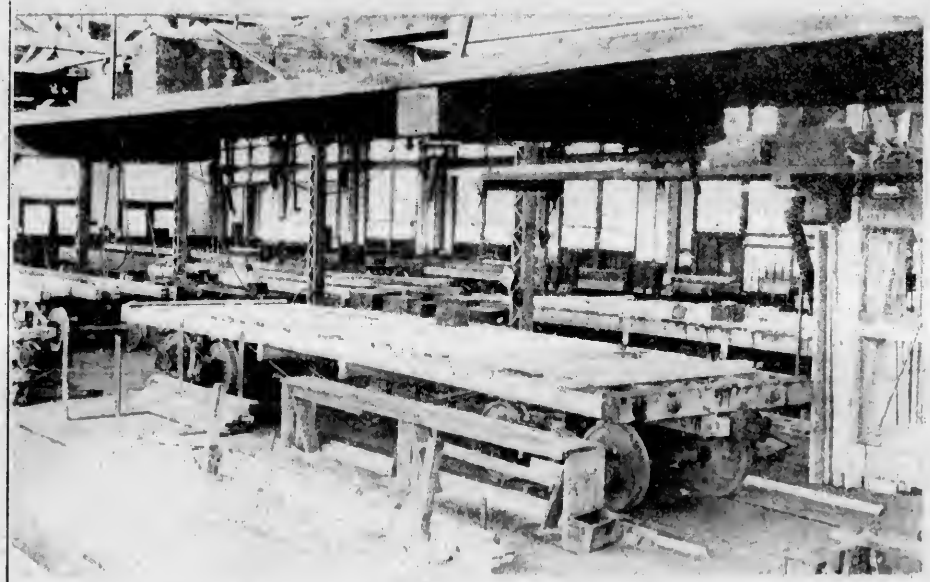
58



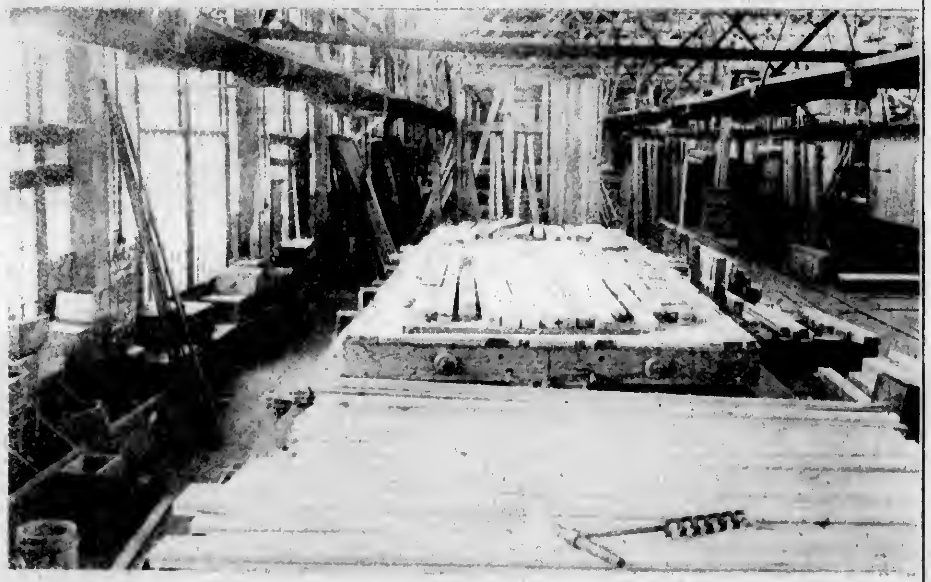
57



59



60



61

Fig. 57.—A Car in the Second Stage of Erection. Draft Rigging Assembling Devices Shown Alongside the Car at Each End. Bolt Bins in the Rear. Fig. 58.—Device for Putting Springs and Followers in Draft Sills. Fig. 59.—Looking Down One of the Erecting Tracks. A Car in the Second Stage of Erection in the Foreground. Fig. 60.—The Third Stage—Laying the Floor. Fig. 61.—The Fourth Stage. The Roof Frame Will Next be Built.

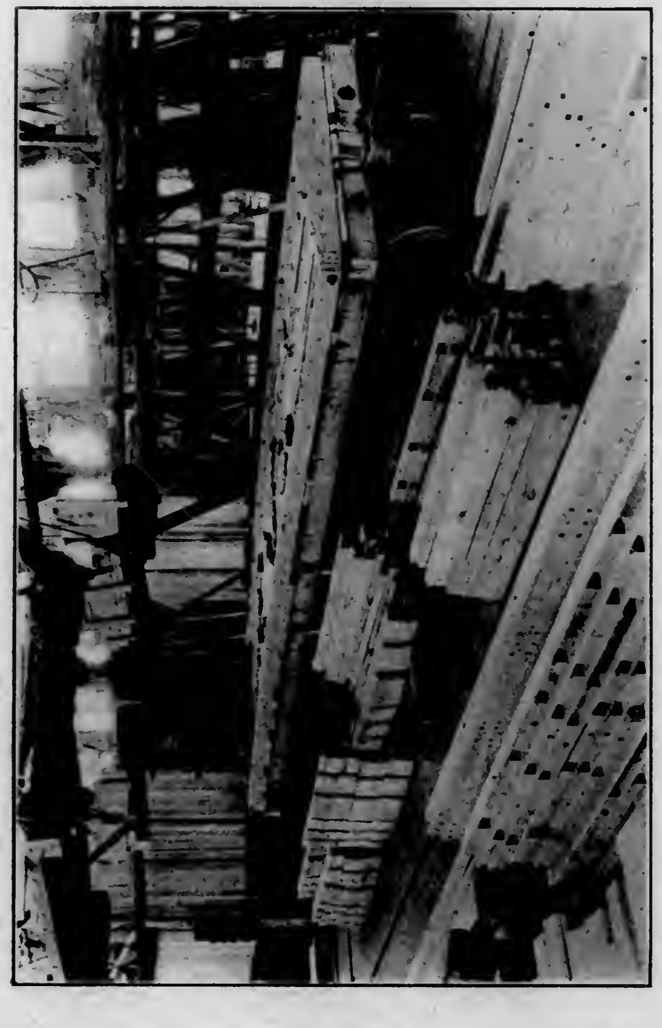


FIG. 62.—FOURTH STAGE—THE ROOF FRAME IS IN PROCESS OF BUILDING.

FIG. 63.—FOURTH STAGE—THE ROOF FRAME IS ABOUT TO BE RAISED.

FIG. 65.—THE FOURTH STAGE COMPLETED.

FIG. 66.—THE FIFTH STAGE—PUTTING ON THE SIDING.

The west end of the shop, near the dry kiln, is used for finishing sheathing, roofing and flooring as it comes from the dry kiln. The pieces are planed, cut to length and passed through holes in the doors or wall and loaded on trucks and taken to the freight car shop or temporarily piled just outside the mill. A view of one of the planers and a cut-off saw is shown in Fig. 53. The track which extends across the shop from the entrance nearest the dry kiln may be seen where it crosses the longitudinal track.

Freight Car Shop.*

The freight car shop is the most interesting part of the plant. The same general features which were emphasized in connection with the building of the trucks are true of the erecting of the car bodies, except that they are applied on a much larger and more important scale. The trucks with the body bolsters set on them are brought in at one end of the shop and the work of erecting the car body is divided into several stages. A certain number of men are detailed for each stage of the work. When the gangs have completed their tasks (and the work is so divided that they get through at about the same time) the cars in the various stages of erection are coupled together by spacing rods, 10 ft. long, and all are pulled forward one length by an electric haul. While the cars are being pulled ahead the men usually work right along and the efficiency of each man and the gang as a whole is thereby considerably increased. The use of the electric haul practically increased the shop output four cars per day. This method of erecting the cars incidentally greatly simplifies the handling of material. The same kind of material is delivered to the same place alongside the erecting track, by the laboring gangs, each time, and if they do get confused as to its location the workmen are not slow to correct them. Walking down through the shop the cars may be seen in the various stages of erection.

The stages in general are as follows: First the trucks are brought in at the end of the shop, the truss rod posts are bolted to the bolsters, the centre pin is applied, and bolts for attaching the centre sills are laid in place. Second, the underframe is erected. Third, the flooring is laid. Fourth, the body framing is erected. Fifth, the siding and inside end sheathing are applied and the galvanized iron roof is laid. Sixth, the inside of the car is finished, the outside trimmings are put in place, the roof is finished and the brakes are applied. Seventh, the running board is laid.

There are six longitudinal tracks in the building, two for material and four for erecting purposes. In all about 200 men are employed on actual erecting work, divided into four gangs of 50 men each. Each erecting track is overlooked by a gang foreman.

Possibly the best way of presenting a clear idea of this work would be to consider the various operations of building the car in more or less detail.

First Stage.—The trucks are brought into the end of the shop and one of the men in the gang engaged upon the second stage slips back, as he can find time, and bolts the truss rod posts on the top of the body bolster, puts in the centre pin and lays the sill bolts on top of the bolster.

The bolts are stored near the entrance of the shop in bins, shown in Figs. 54 and 55. They are delivered from the machine shop on lorry trucks in the boxes (see Figs. 27, 29 and 36). These boxes hold 600 or 700 lbs. of bolts and six of them are loaded on each truck. One man has charge of seeing that they are properly distributed in the freight car shop. The boxes are lifted by an air hoist which operates on a U-shaped track, with the legs of the U extending over the bins on each side of the track. When the box is over the proper bin a hook from a chain which is suspended from above the hoist, is fastened in an eye in the bottom of the box. As the hoist is lowered the box is gradually tipped and emptied into the bin. When the bins are full the workmen can easily reach the bolts, standing on the floor. A step has been attached to the side of the bins, as shown, to facilitate reaching the bolts when they are only partially full.

Fig. 55 is a view looking down one of the material tracks, showing the bolt bins on either side and the three 2,000-lb. Whiting cranes extending over two erecting tracks and the material track. These traveling cranes are equipped with air hoists. The two nearer ones are used principally for hoisting the sills into place, and the third one is used for hoisting the roof frame; its length of travel is restricted, as is noted later.

A simple device for bending a truss rod complete in one operation is shown in Fig. 56. It consists of a frame work with two air cylinders and the necessary guides and stops for properly shaping the rod. The handle for operating the device is shown above the top member of the frame, at about the middle. A duplicate set of cylinders, etc., are attached to the other side of the framework for bending the rods for use on the far side of the shop. The different cars in the various stages of erection, when they are ready to be moved, are connected together by spacing rods, and by means of a motor driven winch are pulled forward the proper distance.

Second Stage.—The two trucks are moved forward and the men in the first gang start to work on the underframe. Two men place the center sub-sills, which fit between the needle beams and bolster, with the bolster ends resting on the inner truck axles. The needle beams are placed near the ends of these sills. Meanwhile two of the men have swung the side sills into place with the aid of a crane. A fifth man has been engaged in fitting the draft rigging together with the device shown in Figs. 57 and 58. This consists of a simple framework with two air cylinders mounted upon it. The cheek plates are first bolted to the sills, and after the sills have been bolted together the springs and draft lugs are forced in place by the air cylinders. The two men working on the side sills put the corner post pockets in place and the two men underneath the car put up the needle beams. The center sills are then put in place. The intermediate sills are placed and bolted. A car at about this stage of construction is shown in Figs. 57 and 59. The former shows the arrangement of the bolt bins, and also the location of the draft rigging assembling devices, one being placed at each end of each car. Fig. 59 shows cars in the second, third and fourth stages of erection. The queen posts are next placed on the needle beams. By this time the draft rigging has been assembled and is swung into place with a crane and bolted by the vertical bolts through the sills. The two men underneath the car put up the brake cylinder. The truss rods are put in place and the end sills erected. Red preservative paint is put on the tops of the sills; turn buckles are applied to the truss rods. Pocket castings are placed on top of the sills for the frame posts. Meanwhile one of the men has found time to go back and put the truss rod posts on the two body bolsters on the trucks at the rear, which the laboring gang have brought into the shop. The underframe is complete when it leaves this gang, except that the truss rods are not drawn up and the dead woods are not applied.

Third Stage.—When the car is pulled forward a gang of four men lay the flooring. Usually they find time to go back and put some of the flooring on the frame before the car has been moved forward. Two of the men fit the flooring, starting from the middle of the car, boring it where necessary because of projecting bolt heads, or cutting it out with an axe where it has to be fitted over large washers. It is also necessary to cut the flooring to fit between the post castings. The two men who are nailing start most of the nails and then drive them home with a heavy hammer. While the two men are doing the heavy nailing the two fitters are arranging the floor timbers at the ends. The car shown in Fig. 60 is in about this stage of construction. The belt rails which are to be used in the next stage of construction are shown in the foreground where they can readily be piled on when the floor is finished and be ready for the next stage (see Fig. 61). The final operation is to lay off the deck boards and cut them to the proper length at the side door. The men who finish first start to get the material ready for the next car.

Fourth Stage.—The men first arrange the side posts and belt rails, etc., on the floor of the car, as shown in Fig. 61. This material is carefully placed so that when the roof frame is raised it may be assembled quickly. The belt rails, which are shown more in detail in Fig. 64, are either made from one piece on a special machine in the planing mill, or are built up from a num-

* The building was described on page 4 of the January, 1905, issue.

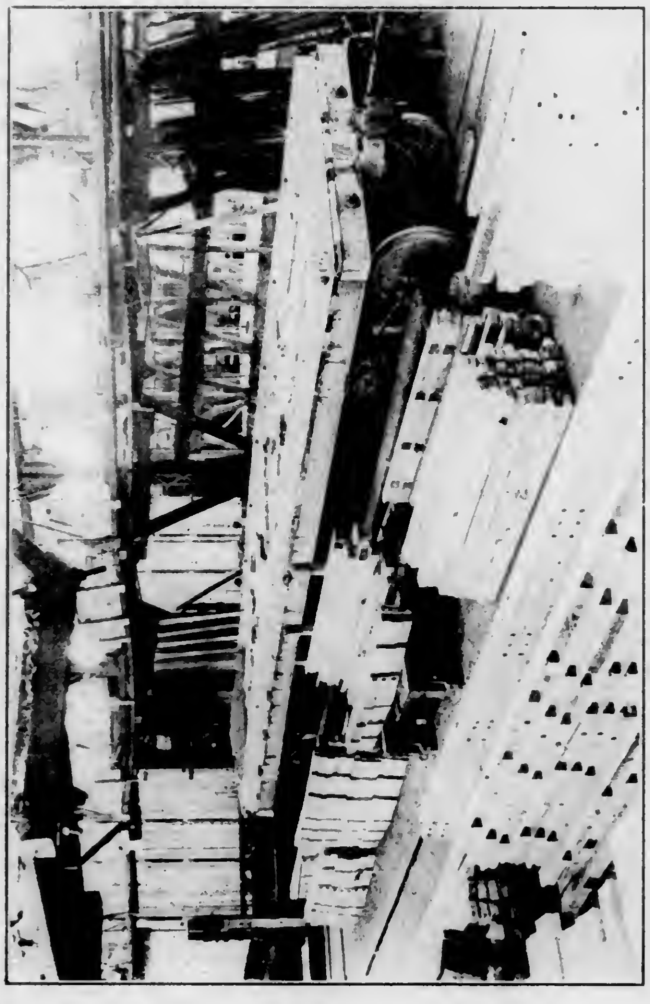


FIG. 62.—FOURTH STAGE—THE ROOF FRAME IS IN PROCESS OF BUILDING.

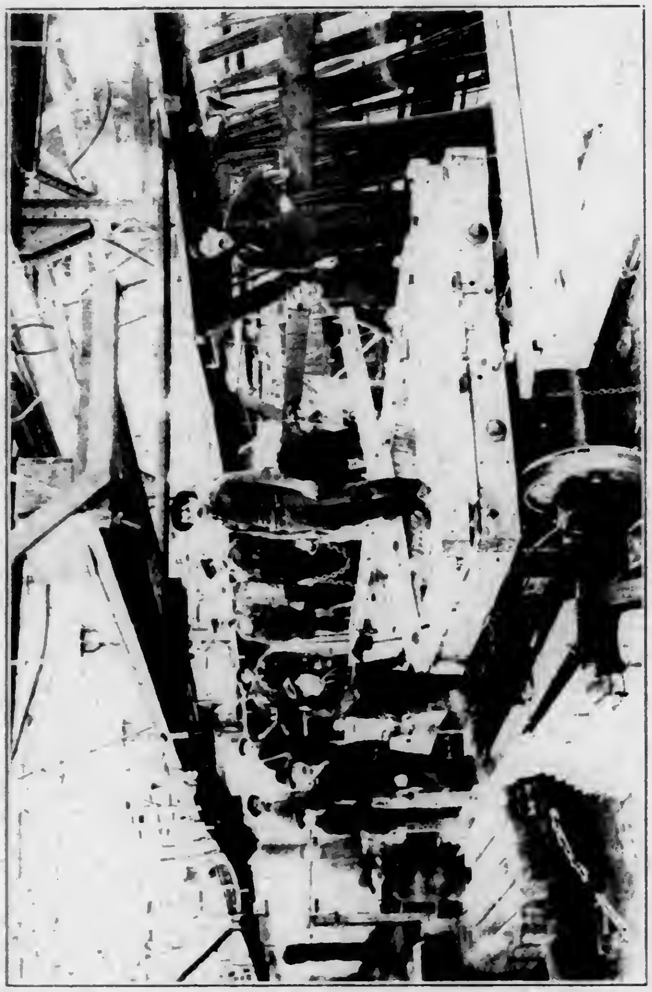


FIG. 63.—FOURTH STAGE—THE ROOF FRAME IS ABOUT TO BE RAISED.

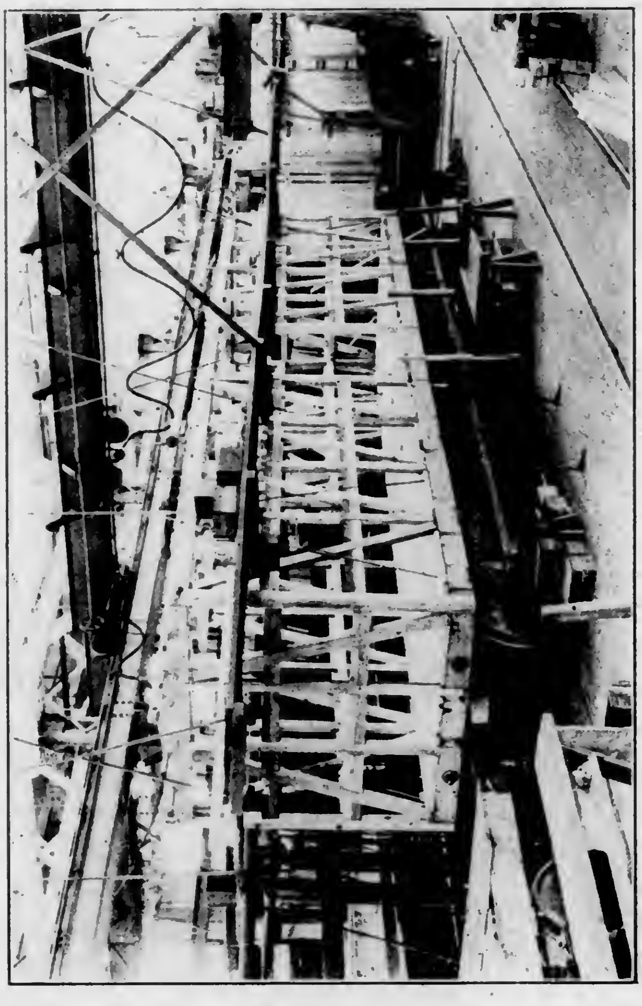


FIG. 65.—THE FOURTH STAGE COMPLETED.

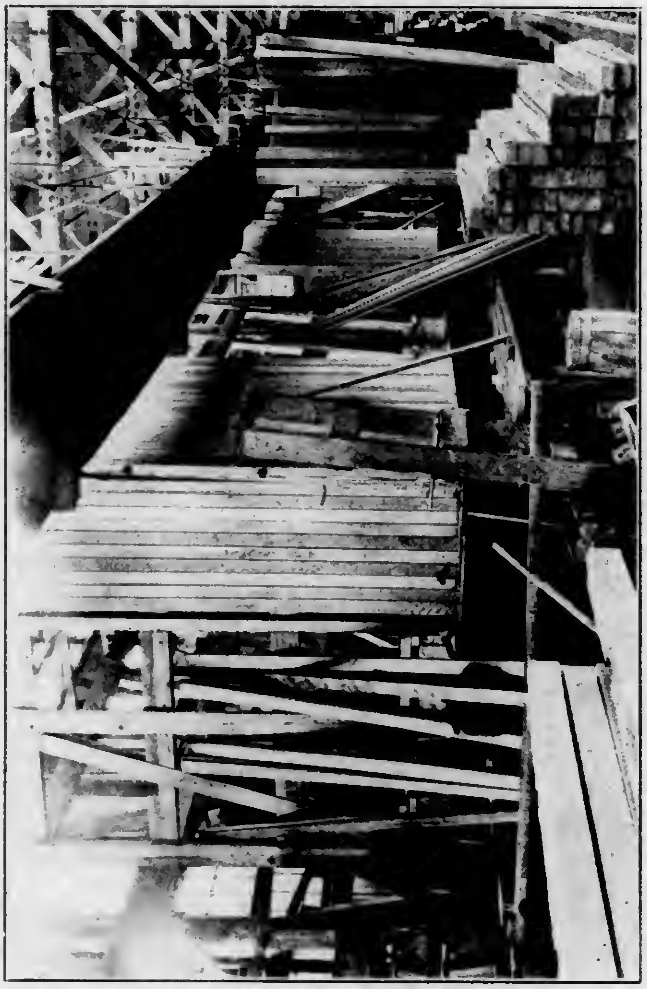


FIG. 66.—THE FIFTH STAGE—PUTTING ON THE SIDING.

The west end of the shop, near the dry kiln, is used for finishing sheathing, roofing and flooring as it comes from the dry kiln. The pieces are planed, cut to length and passed through holes in the doors or wall and loaded on trucks and taken to the freight car shop or temporarily piled just outside the mill. A view of one of the planers and a cut-off saw is shown in Fig. 53. The track which extends across the shop from the entrance nearest the dry kiln may be seen where it crosses the longitudinal track.

Freight Car Shop.*

The freight car shop is the most interesting part of the plant. The same general features which were emphasized in connection with the building of the trucks are true of the erecting of the car bodies, except that they are applied on a much larger and more important scale. The trucks with the body bolsters set on them are brought in at one end of the shop and the work of erecting the car body is divided into several stages. A certain number of men are detailed for each stage of the work. When the gangs have completed their tasks (and the work is so divided that they get through at about the same time) the cars in the various stages of erection are coupled together by spacing rods, 10 ft. long, and all are pulled forward one length by an electric haul. While the cars are being pulled ahead the men usually work right along and the efficiency of each man and the gang as a whole is thereby considerably increased. The use of the electric haul practically increased the shop output four cars per day. This method of erecting the cars incidentally greatly simplifies the handling of material. The same kind of material is delivered to the same place alongside the erecting track, by the laboring gangs, each time, and if they do get confused as to its location the workmen are not slow to correct them. Walking down through the shop the cars may be seen in the various stages of erection.

The stages in general are as follows: First, the trucks are brought in at the end of the shop, the truss rod posts are bolted to the bolsters, the centre pin is applied, and bolts for attaching the centre sills are laid in place. Second, the underframe is erected. Third, the flooring is laid. Fourth, the body framing is erected. Fifth, the siding and inside end sheathing are applied and the galvanized iron roof is laid. Sixth, the inside of the car is finished, the outside trimmings are put in place, the roof is finished and the brakes are applied. Seventh, the running board is laid.

There are six longitudinal tracks in the building, two for material and four for erecting purposes. In all about 200 men are employed on actual erecting work, divided into four gangs of 50 men each. Each erecting track is overlooked by a gang foreman.

Possibly the best way of presenting a clear idea of this work would be to consider the various operations of building the car in more or less detail.

First Stage.—The trucks are brought into the end of the shop and one of the men in the gang engaged upon the second stage slips back, as he can find time, and bolts the truss rod posts on the top of the body bolster, puts in the centre pin and lays the sill bolts on top of the bolster.

The bolts are stored near the entrance of the shop in bins, shown in Figs. 54 and 55. They are delivered from the machine shop on lorry trucks in the boxes (see Figs. 27, 29 and 36). These boxes hold 600 or 700 lbs. of bolts and six of them are loaded on each truck. One man has charge of seeing that they are properly distributed in the freight car shop. The boxes are lifted by an air hoist which operates on a U-shaped track, with the legs of the U extending over the bins on each side of the track. When the box is over the proper bin a hook from a chain which is suspended from above the hoist, is fastened in an eye in the bottom of the box. As the hoist is lowered the box is gradually tipped and emptied into the bin. When the bins are full the workmen can easily reach the bolts, standing on the floor. A step has been attached to the side of the bins, as shown, to facilitate reaching the bolts when they are only partially full.

Fig. 55 is a view looking down one of the material tracks, showing the bolt bins on either side and the three 2,000-lb. Whiting cranes extending over two erecting tracks and the material track. These traveling cranes are equipped with air hoists. The two nearer ones are used principally for hoisting the sills into place, and the third one is used for hoisting the roof frame; its length of travel is restricted, as is noted later.

A simple device for bending a truss rod complete in one operation is shown in Fig. 56. It consists of a frame work with two air cylinders and the necessary guides and stops for properly shaping the rod. The handle for operating the device is shown above the top member of the frame, at about the middle. A duplicate set of cylinders, etc., are attached to the other side of the framework for bending the rods for use on the far side of the shop. The different cars in the various stages of erection, when they are ready to be moved, are connected together by spacing rods, and by means of a motor driven winch are pulled forward the proper distance.

Second Stage.—The two trucks are moved forward and the men in the first gang start to work on the underframe. Two men place the center sub-sills, which fit between the needle beams and bolster, with the bolster ends resting on the inner truck axles. The needle beams are placed near the ends of these sills. Meanwhile two of the men have swung the side sills into place with the aid of a crane. A fifth man has been engaged in fitting the draft rigging together with the device shown in Figs. 57 and 58. This consists of a simple framework with two air cylinders mounted upon it. The cheek plates are first bolted to the sills, and after the sills have been bolted together the springs and draft lugs are forced in place by the air cylinders. The two men working on the side sills put the corner post pockets in place and the two men underneath the car put up the needle beams. The center sills are then put in place. The intermediate sills are placed and bolted. A car at about this stage of construction is shown in Figs. 57 and 59. The former shows the arrangement of the bolt bins, and also the location of the draft rigging assembling devices, one being placed at each end of each car. Fig. 59 shows cars in the second, third and fourth stages of erection. The queen posts are next placed on the needle beams. By this time the draft rigging has been assembled and is swung into place with a crane and bolted by the vertical bolts through the sills. The two men underneath the car put up the brake cylinder. The truss rods are put in place and the end sills erected. Red preservative paint is put on the tops of the sills; turn buckles are applied to the truss rods. Pocket castings are placed on top of the sills for the frame posts. Meanwhile one of the men has found time to go back and put the truss rod posts on the two body bolsters on the trucks at the rear, which the laboring gang have brought into the shop. The underframe is complete when it leaves this gang, except that the truss rods are not drawn up and the dead woods are not applied.

Third Stage.—When the car is pulled forward a gang of four men lay the flooring. Usually they find time to go back and put some of the flooring on the frame before the car has been moved forward. Two of the men fit the flooring, starting from the middle of the car, boring it where necessary because of projecting bolt heads, or cutting it out with an axe where it has to be fitted over large washers. It is also necessary to cut the flooring to fit between the post castings. The two men who are nailing start most of the nails and then drive them home with a heavy hammer. While the two men are doing the heavy nailing the two fitters are arranging the floor timbers at the ends. The car shown in Fig. 60 is in about this stage of construction. The belt rails which are to be used in the next stage of construction are shown in the foreground where they can readily be piled on when the floor is finished and be ready for the next stage (see Fig. 61). The final operation is to lay off the deck boards and cut them to the proper length at the side door. The men who finish first start to get the material ready for the next car.

Fourth Stage.—The men first arrange the side posts and belt rails, etc., on the floor of the car, as shown in Fig. 61. This material is carefully placed so that when the roof frame is raised it may be assembled quickly. The belt rails, which are shown more in detail in Fig. 64, are either made from one piece on a special machine in the planing mill, or are built up from a num-

* The building was described on page 1 of the January, 1905, issue.

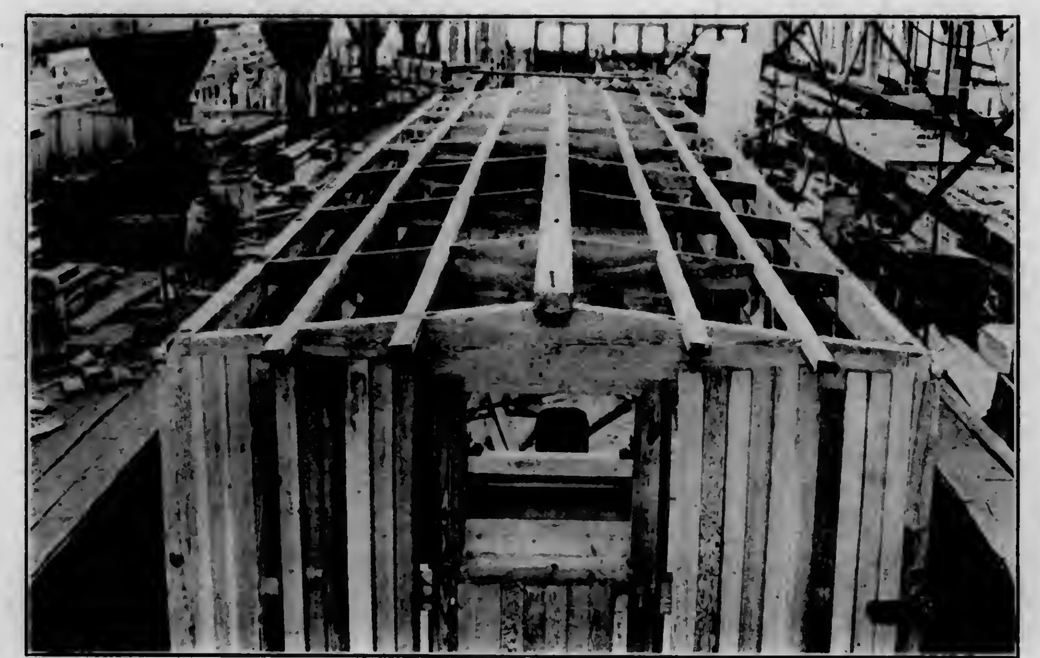


FIG. 67.—A VIEW DURING THE FIFTH STAGE.

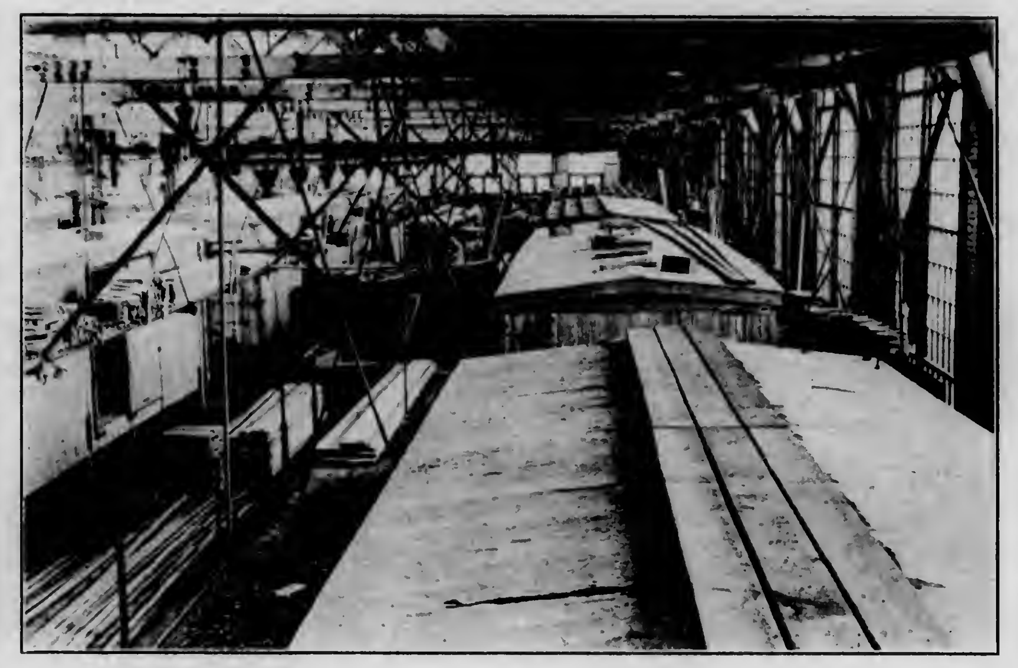


FIG. 68.—SHOWING ROOFS IN THE FOURTH, FIFTH, SIXTH AND SEVENTH STAGES OF CONSTRUCTION

FIG. 69.—PNEUMATIC DEVICE FOR BENDING BRAKE PIPES COMPLETE IN ONE OPERATION.

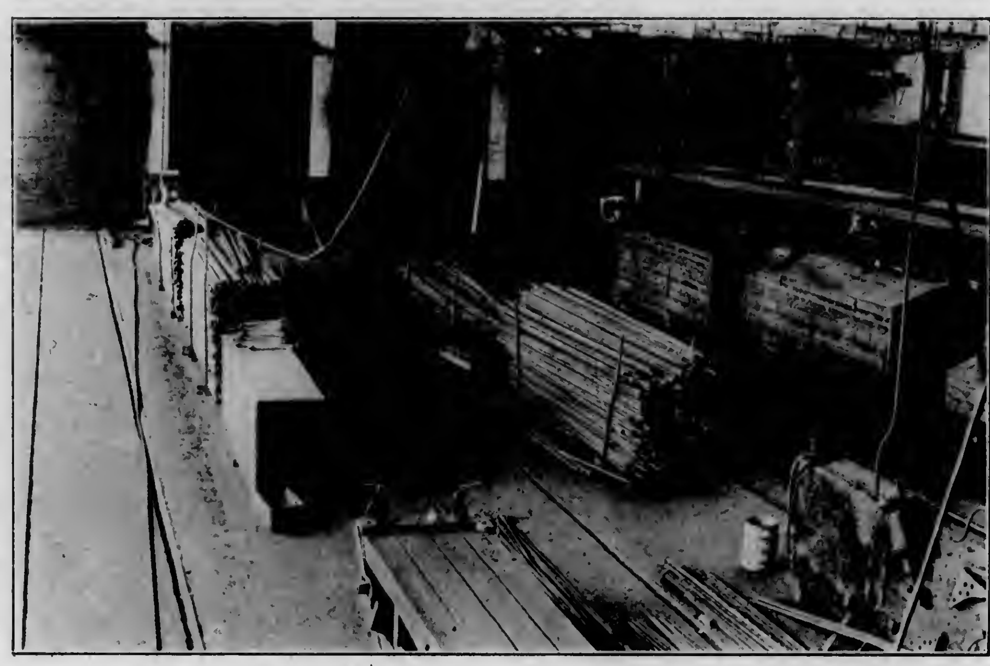


FIG. 70.—LOOKING FROM THE TOP OF A FINISHED CAR TOWARD THE PAINT SHOP.

ber of pieces, as shown in the illustration. This work is done by one of the men in the body frame gang in the erecting shop. The small pieces are made from short lengths which cannot be used for other purposes. They are assembled to template.

The frame of the roof is built around and to receive these parts (Figs. 62 and 63), and when it has been completed the long vertical rods are dropped through the holes in the framing and the roof frame is hoisted by a crane. This crane is used for this purpose only, and because of the rods which support the platform alongside the car, cannot be moved away from this place. While the roof is held suspended the side, corner and end posts are fitted into the castings on the underframe, the braces are fitted and when this is all arranged the roof framing is lowered over it and it is forced down into place with sledges; the belt rails are applied, and the various vertical and diagonal rods are tightened up (Fig. 65). There are ten men in this gang.

FIG. 72.—SIDE VIEW OF THE PAINT AND FREIGHT CAR SHOPS. PAINT SHOP AT THE RIGHT.
FIG. 74.—ONE DAY'S OUTPUT.
FIG. 73.—THE FINISHED CAR, READY FOR WEIGHING.
FIG. 71.—STORAGE OF MATERIAL ALONG THE NORTH SIDE OF THE CAR SHOP.

Fifth Stage.—The siding (Figs. 66 and 67) and inside end lining are put on and the galvanized iron roofing is laid. Twelve men are engaged upon this. It includes also the hanging of the side and end doors, the arranging of the corner bands inside and out, the application of the dead woods and the drawing up of the truss rods.

Sixth Stage.—This includes the finishing of the inside lining and the roof, except the running board. Also the application of the brake pipes and trimmings.

FIG. 64.—BELT RAILS.

Seventh Stage.—This includes the laying of the running boards, the application of the foundation brake gear, finishing the trimmings and the cleaning out of the car. The last four stages, as far as the roof construction is concerned, are clearly shown in Fig. 68. One man attends to packing the journal boxes for all four gangs.

At the end of the shop nearest the paint shop are several tools, including a grindstone, pipe cutters, and rip saw. Here also are kept the supplies of pipe for the brakes and the nuts, washers, nails and screws. A special pipe bending device is used, shown in Figs. 69 and 70. The pipe is bent complete in one operation. It is bent sidewise by a third air cylinder, the plunger of which is shown near the bottom of the frame at about the middle.

The bins containing the nails, screws, washers, nuts and nut

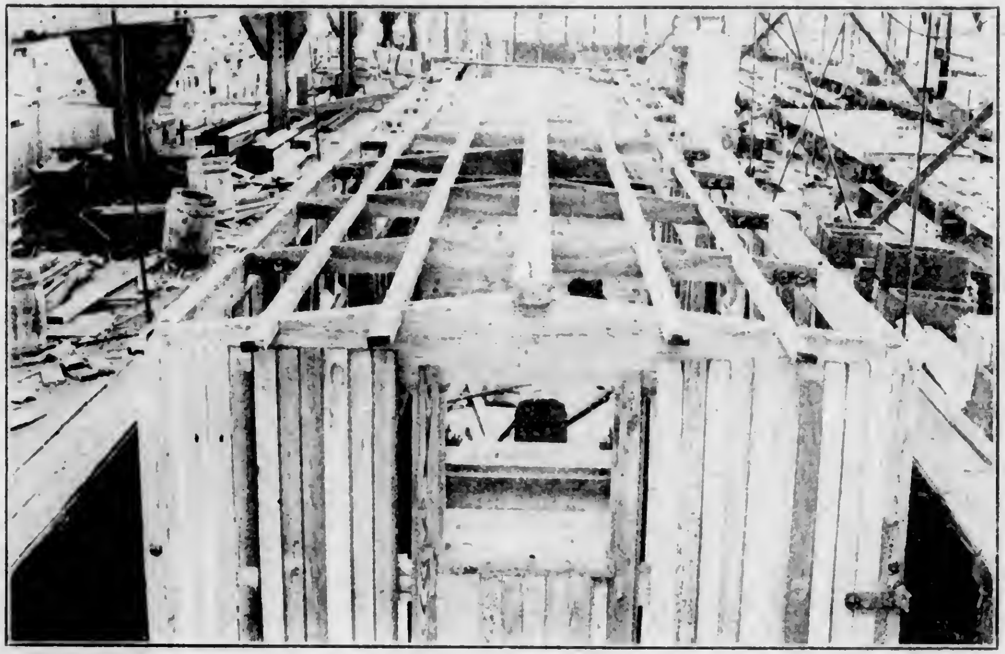


FIG. 67.—A VIEW DURING THE FIFTH STAGE.

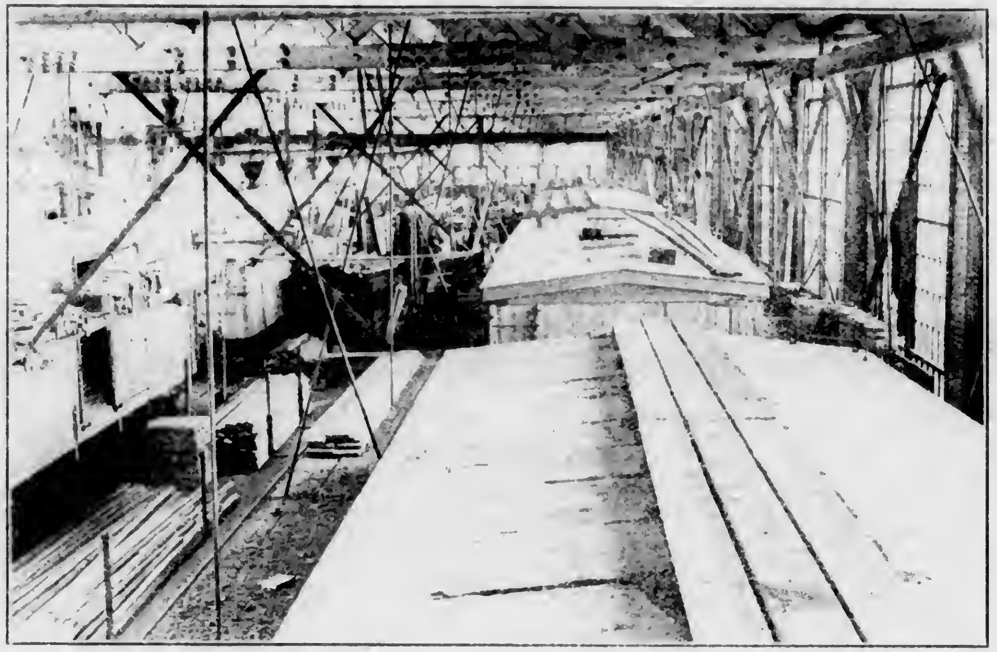


FIG. 68.—SHOWING ROOFS IN THE FOURTH, FIFTH, SIXTH AND SEVENTH STAGES OF CONSTRUCTION.

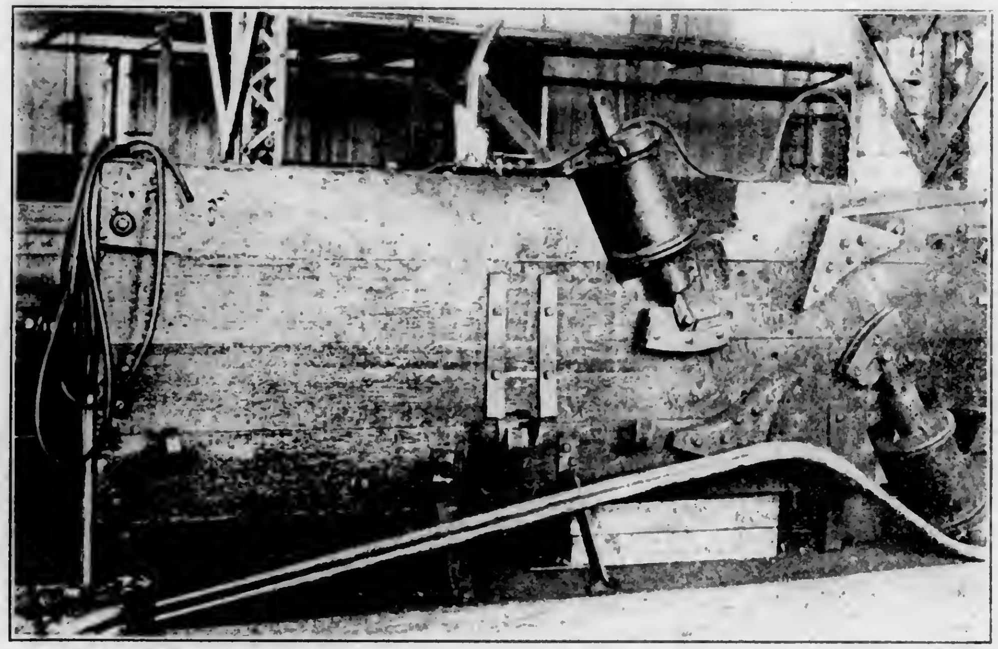


FIG. 69.—PNEUMATIC DEVICE FOR BENDING BRAKE PIPES COMPLETE IN ONE OPERATION.

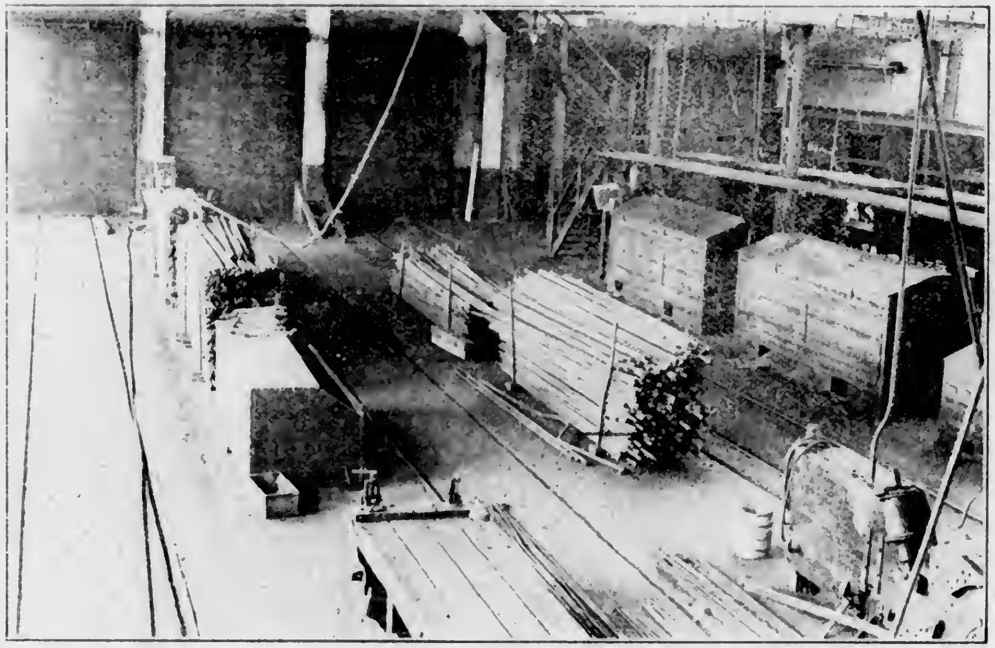


FIG. 70.—LOOKING FROM THE TOP OF A FINISHED CAR TOWARD THE PAINT SHOP.

ber of pieces, as shown in the illustration. This work is done by one of the men in the body frame gang in the erecting shop. The small pieces are made from short lengths which cannot be used for other purposes. They are assembled to template.

The frame of the roof is built around and to receive these parts (Figs. 62 and 63), and when it has been completed the long vertical rods are dropped through the holes in the framing and the roof frame is hoisted by a crane. This crane is used for this purpose only, and because of the rods which support the platform alongside the car, cannot be moved away from this place. While the roof is held suspended the side, corner and end posts are fitted into the castings on the underframe, the braces are fitted and when this is all arranged the roof framing is lowered over it and it is forced down into place with sledges; the belt rails are applied, and the various vertical and diagonal rods are tightened up (Fig. 65). There are ten men in this gang.

Fifth Stage.—The siding (Figs. 66 and 67) and inside end lining are put on and the galvanized iron roofing is laid. Twelve men are engaged upon this. It includes also the hanging of the side and end doors, the arranging of the corner bands inside and out, the application of the dead woods and the drawing up of the truss rods.

Sixth Stage.—This includes the finishing of the inside lining and the roof, except the running board. Also the application of the brake pipes and trimmings.

Fig. 64.—Belt Rails.

Seventh Stage.—This includes the laying of the running boards, the application of the foundation brake gear, finishing the trimmings and the cleaning out of the car. The last four stages, as far as the roof construction is concerned, are clearly shown in Fig. 68. One man attends to packing the journal boxes for all four gangs.

At the end of the shop nearest the paint shop are several tools, including a grindstone, pipe cutters, and rip saw. Here also are kept the supplies of pipe for the brakes and the nuts, washers, nails and screws. A special pipe bending device is used, shown in Figs. 69 and 70. The pipe is bent complete in one operation. It is bent sidewise by a third air cylinder, the plunger of which is shown near the bottom of the frame at about the middle.

The bins containing the nails, screws, washers, nuts and nut

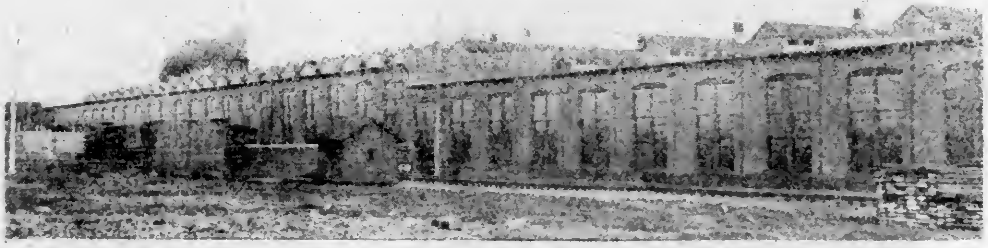


Fig. 72.—Side View of the Paint and Freight Car Shops. Paint Shop at the Right.
Fig. 74.—One Day's Output.
Fig. 73.—The Finished Car, Ready for Weighing.
Fig. 71.—Storage of Material Along the North Side of the Car Shop.

locks, are locked at the top and have openings at the bottom, as shown in Fig. 70, from which the material is removed. Seven hundred kegs of nails may be stored in these bins. The lumber when it is brought into the shop is piled in U-shaped cradles. It does not have to be piled as carefully in this way, thus saving more or less time.

As noted at the beginning of this article, 28 standard 60-ton box cars have been regularly turned out in a day of ten hours with a force of about 200 men, or fifty men to a gang. In addition one man mixes the oil and waste for packing; one man packs all the boxes; there are six men in the pipe gang; one man looks after the bolts, etc.; there are four sweepers or cleaners; thirteen men are required to bring in the timber, which approximates 125,000 ft. per day. The general foreman, Mr. Hailey, has two assistant foremen in this shop.

The castings, draft springs, metal roofing, etc., are stored outside the shop and the rods are stored in bins similar to those illustrated in Fig. 38. Some of the material, outside the north side of the shop, mostly roofing, is shown in Fig. 71. The workmen are required to bring in the castings and roofing material which they use.

Painting.

The sliding doors between the freight car shop and the paint shop are shown in Fig. 70. The cars are pulled into the paint shop by the motor driven winches which are also partly shown in this view. The paint shop is 321 ft. long and contains 6 longitudinal tracks.

The cars are painted with spraying machines which were developed at these shops. Six men are required for this work and six for stenciling. Two coats of paint are applied and the cars are usually completed by the second evening after their erection. One man gives all his time to mixing and issuing the paint. This is done in a small addition to the freight car shop, the packing being handled in the same place.

A side view of the paint shop building, also the freight car shop, is shown in Fig. 72.

Inspecting and Weighing.

One man, who reports directly to the general foreman of the freight car department, inspects the cars carefully and sees that they are turned out in first-class condition. The finished car is shown in Fig. 73. One day's output, ready to be pulled out and weighed on the scale, shown northeast of the paint shop on the general plan, is shown in Fig. 74.

We gratefully acknowledge indebtedness for information and courtesies to the officers and men of the car department.

CAR STATISTICS.—Bulletin No. 14 of the American Railway Association, Committee on Car Efficiency gives some very interesting information concerning car performances for the month of August, 1907. While this information is given for each individual road a recapitulation for the whole country is included and shows conditions during that month to have produced the following results:

Total cars in service	2,060,066
Per cent. of home cars on line	62
Per cent. of cars in shop	6.21
Number of cars on line per freight locomotive owned	65
Average miles per car per day	24.1
Per cent. loaded mileage	70.8
Average tonnage	14.6
Average tonnage per loaded car	20.8
Average ton miles per car per day	351
Daily earnings per car owned	$2.59
Average earnings of cars on line per day	$2.44

To succeed is to study and when one quits studying his business he should at that time make up his mind that he attained his limit of success and the next change for him is a start on the "toboggan" just as sure as day follows night. This applies to the engineman who cannot be shown as well as to all others in the organization.—*Mr. D. R. MacBain before the Traveling Engineers' Association.*

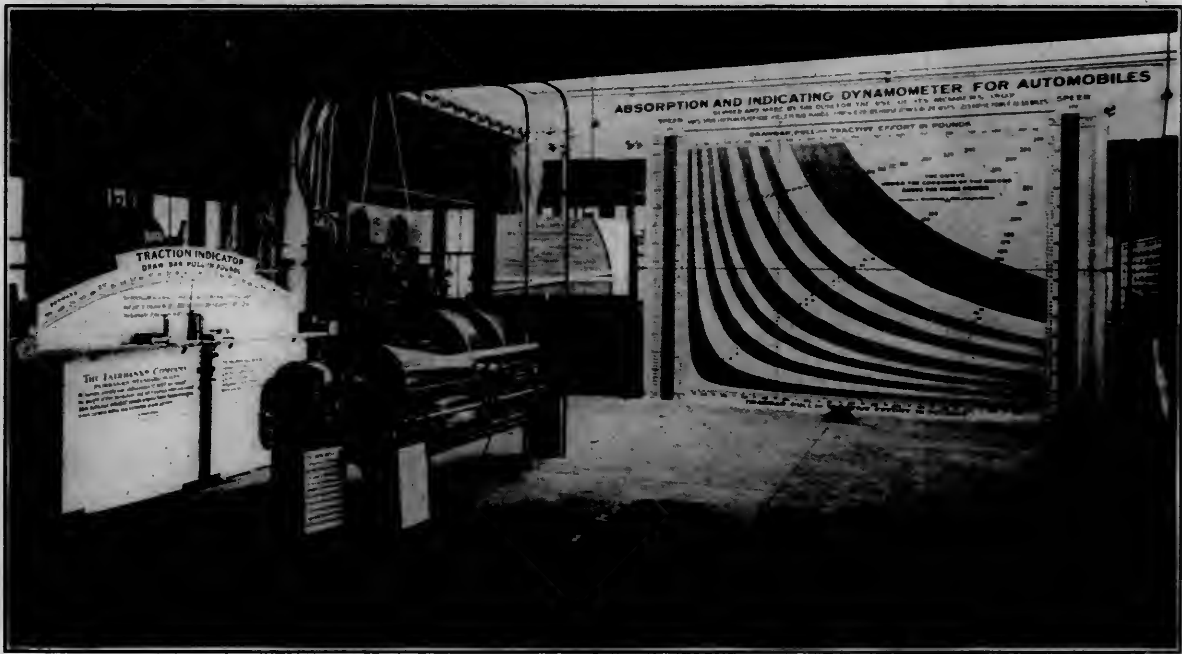
TESTING MACHINE FOR AUTOMOBILES.

There has recently been put into operation at the New York Club House of the Automobile Club of America a very interesting machine for accurately testing all of the more important features of automobile operation. This machine will accurately indicate the speed of a car, the tractive effort in pounds, the horse-power which is being delivered at the contact of the rear wheels, the grade in per cent. or feet which the car could climb at this speed, the inclination on which the brakes would hold the car, the internal friction of the car or engine and other similar information. The whole apparatus, which in principle is modeled somewhat after a locomotive testing plant, was designed by Dr. S. S. Wheeler, vice-president of the club and president of the Crocker-Wheeler Company. Many features of the absorbing and recording instruments are entirely original and most interesting.

The general features of the dynamometer are shown in the illustrations, and in brief consist of two large wheels, on which the driving wheels of the automobile rest, mounted on a shaft supported below the floor and having their upper edges projecting above the floor level. This shaft connects through a clutch to an Alden friction brake, which absorbs the power from the shaft by transferring it to the movement of a huge pendulum, which is seen hanging from the shaft at the left in the lower illustration. The movement of this pendulum from the vertical is an accurate indication of the amount of power absorbed by the friction brake and is recorded in pounds by a pointer on the scale shown on the extreme left in the upper illustration, this scale being laid off proportional to the sine of the angle at which the pendulum is swung from the vertical. The speed of cars is recorded directly from the dynamometer shaft, allowance being made for the difference in diameter of the wheels, by a very ingenuous instrument which will be described.

One of the most valuable features of this plant is the transferring of these speed and tractive effort readings to a large chart directly in front of the car being tested. This chart, as can be seen in the illustration, has vertical scales showing the speed in any desired unit and horizontal scales showing the tractive effort in pounds. The cross rulers, giving these indications, are operated by cables, whose movement is controlled by electric motors. These motors are operated through electric contact devices so as to closely follow the movement of the pointer showing the tractive effort and transfer the reading accurately to the large scale, and also from the speed meter to the large scale. This construction is so accurate that the slightest variation in either is instantly followed by change in position of the ruler on the large chart.

The transferring of the record of the speed to the cross ruler on the chart is accomplished by a special apparatus of considerable novelty. This is shown as located in the left foreground of the upper illustration and consists primarily of a cone which is revolved at absolutely constant speed by an electric motor. This speed is verified by a bell attached to the cone shaft, which rings at each 100 revolutions or at intervals of 30 seconds, since the cone revolves at 200 r.p.m. The speed of the dynamometer shaft is transferred by shafts and bevel gears to a shaft parallel to the surface of the cone. A wheel or roller is driven by a light frictional connection to this shaft, being so arranged that it has a free movement along the shaft and tends to revolve at the same speed. The circumference of the wheel, however, rests against the surface of the cone with sufficient pressure to cause it to revolve at the same speed as that particular part of the cone with which it is in contact. This causes a slipping in its connection to the shaft which brings electric contacts into action and starts a small motor. This motor by a cable connection pulls the wheel along the shaft until it finds a point on the cone which will cause it to revolve at the same speed as the shaft. When that condition is attained the motor controlling its movement is held idle, but any change in the speed which will permit a slip in either direction will again put the motor in operation and change the location of the roller to a new position on the cone. The horizontal movement of this wheel is transferred by the same cables to the horizontal ruler on the big chart.



GENERAL VIEW OF AUTOMOBILE DYNAMOMETER SHOWING LARGE CHART.

PENDULUM, FRICTION BRAKE AND APPARATUS BELOW THE FLOOR.

Since horse-power is a function of speed and tractive effort, both of which are shown on the chart, it was a comparatively simple matter to lay out curves showing the different horse-powers for all different conditions, which will permit the instant reading of the horse-power being delivered at the rear wheels by noting the point at which the two moving scales intersect.

The instrument showing the grade which could be climbed at the speed indicated is controlled by the same cables showing the tractive effort on the chart and consists of a pointer fulcrumed at one end and operated from the horizontal cross piece by a clamp which can be set at the proper weight for the car and its occupants. This scale is laid off proportionally to the sine of the angle of the grade, which equals the tractive effort in pounds divided by the weight of the car in pounds, both to the same scale.

A large motor is provided below the floor, which can be thrown on to the driving shaft by means of a clutch, and thus the amount of power required to drive the car with either the engine connected in, which would give the total internal resistance of the car, or thrown out, which would give the resistance for coasting, can be easily read from the chart, as can also the holding power of the brakes.

This dynamometer and all of the electrical apparatus used thereon was built by the Crocker-Wheeler Company.

CUSSING OF NO VALUE.—One thing to remember is that if a man does not know he cannot be cussed into knowing, especially if you have only a short time in which to give him the treatment. A better plan is to wait an opportunity, and not let it pass when it comes, to talk with the man in a quiet and deliberate manner and do your best to give him such help by way of instruction and advice, as will enable him to do better in the future. These are the correct lines to work along and if results cannot be obtained in such a manner better drop the man, as the cussing process sometimes results in embarrassment to the cusser.—*Mr. D. R. MacBain before the Traveling Engineers' Association.*

TIMBER RESOURCES OF OREGON.—It has been estimated that there is sufficient timber, at present standing in the State of Oregon, to build a solid board fence 50 ft. high around the entire United States.

locks, are locked at the top and have openings at the bottom, as shown in Fig. 70, from which the material is removed. Seven hundred kegs of nails may be stored in these bins. The lumber when it is brought into the shop is piled in U-shaped cradles. It does not have to be piled as carefully in this way, thus saving more or less time.

As noted at the beginning of this article, 28 standard 60-ton box cars have been regularly turned out in a day of ten hours with a force of about 200 men, or fifty men to a gang. In addition one man mixes the oil and waste for packing; one man packs all the boxes; there are six men in the pipe gang; one man looks after the bolts, etc.; there are four sweepers or cleaners; thirteen men are required to bring in the timber, which approximates 125,000 ft. per day. The general foreman, Mr. Hailey, has two assistant foremen in this shop.

The castings, draft springs, metal roofing, etc., are stored outside the shop and the rods are stored in bins similar to those illustrated in Fig. 38. Some of the material, outside the north side of the shop, mostly roofing, is shown in Fig. 71. The workmen are required to bring in the castings and roofing material which they use.

Painting.

The sliding doors between the freight car shop and the paint shop are shown in Fig. 70. The cars are pulled into the paint shop by the motor driven winches which are also partly shown in this view. The paint shop is 321 ft. long and contains 6 longitudinal tracks.

The cars are painted with spraying machines which were developed at these shops. Six men are required for this work and six for stenciling. Two coats of paint are applied and the cars are usually completed by the second evening after their erection. One man gives all his time to mixing and issuing the paint. This is done in a small addition to the freight car shop, the packing being handled in the same place.

A side view of the paint shop building, also the freight car shop, is shown in Fig. 72.

Inspecting and Weighing.

One man, who reports directly to the general foreman of the freight car department, inspects the cars carefully and sees that they are turned out in first-class condition. The finished car is shown in Fig. 73. One day's output, ready to be pulled out and weighed on the scale, shown northeast of the paint shop on the general plan, is shown in Fig. 74.

We gratefully acknowledge indebtedness for information and courtesies to the officers and men of the car department.

CAR STATISTICS.—Bulletin No. 14 of the American Railway Association, Committee on Car Efficiency gives some very interesting information concerning car performances for the month of August, 1907. While this information is given for each individual road a recapitulation for the whole country is included and shows conditions during that month to have produced the following results:

Total cars in service	2,080,066
Per cent. of home cars on line	62
Per cent. of cars in shops	6.21
Number of cars on line per freight locomotive owned	65
Average miles per car per day	21.1
Per cent. loaded mileage	70.8
Average tonnage	11.6
Average tonnage per loaded car	20.8
Average ton miles per car per day	351
Daily earnings per car owned	$2.52
Average earnings of cars on line per day	$2.11

To succeed is to study and when one quits studying his business he should at that time make up his mind that he attained his limit of success and the next change for him is a start on the "toboggan" just as sure as day follows night. This applies to the engineman who cannot be shown as well as to all others in the organization.—*Mr. D. R. MacBain before the Traveling Engineers' Association.*

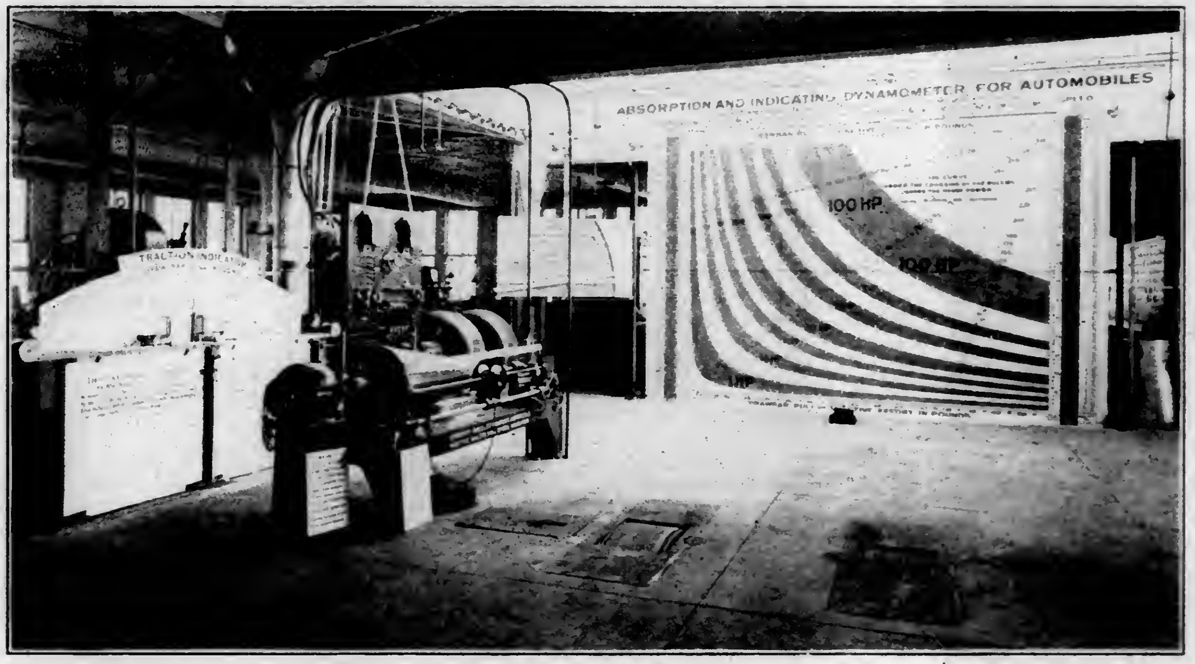
TESTING MACHINE FOR AUTOMOBILES.

There has recently been put into operation at the New York Club House of the Automobile Club of America a very interesting machine for accurately testing all of the more important features of automobile operation. This machine will accurately indicate the speed of a car, the tractive effort in pounds, the horse-power which is being delivered at the contact of the rear wheels, the grade in per cent. or feet which the car could climb at this speed, the inclination on which the brakes would hold the car, the internal friction of the car or engine and other similar information. The whole apparatus, which in principle is modeled somewhat after a locomotive testing plant, was designed by Dr. S. S. Wheeler, vice-president of the club and president of the Crocker-Wheeler Company. Many features of the absorbing and recording instruments are entirely original and most interesting.

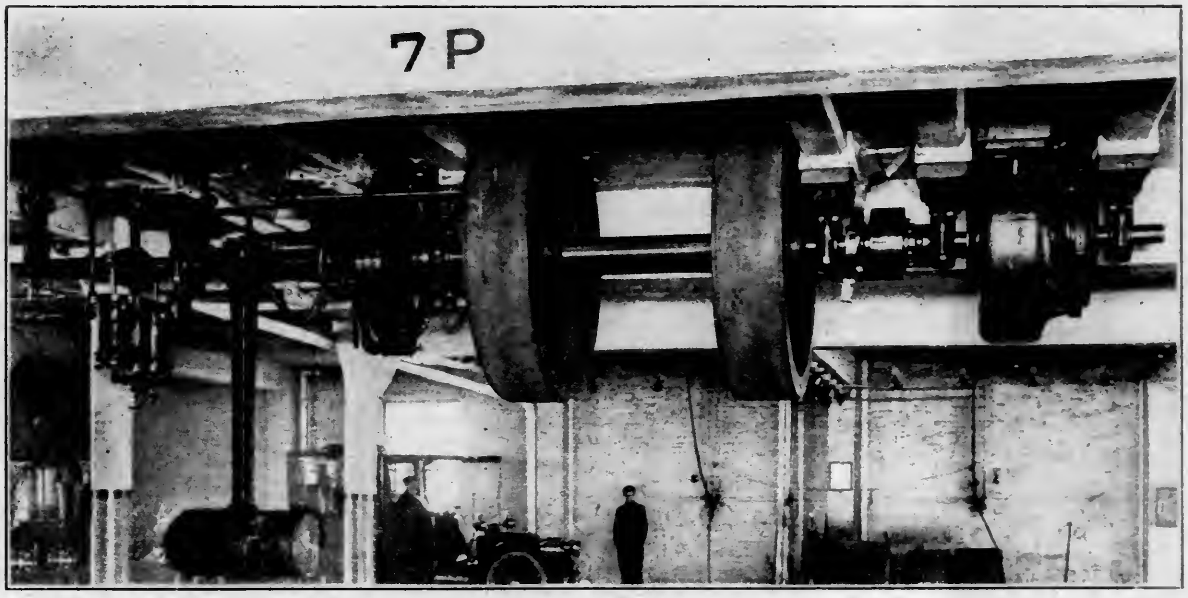
The general features of the dynamometer are shown in the illustrations, and in brief consist of two large wheels, on which the driving wheels of the automobile rest, mounted on a shaft supported below the floor and having their upper edges projecting above the floor level. This shaft connects through a clutch to an Alden friction brake, which absorbs the power from the shaft by transferring it to the movement of a huge pendulum, which is seen hanging from the shaft at the left in the lower illustration. The movement of this pendulum from the vertical is an accurate indication of the amount of power absorbed by the friction brake and is recorded in pounds by a pointer on the scale shown on the extreme left in the upper illustration, this scale being laid off proportional to the sine of the angle at which the pendulum is swung from the vertical. The speed of cars is recorded directly from the dynamometer shaft, allowance being made for the difference in diameter of the wheels, by a very ingenious instrument which will be described.

One of the most valuable features of this plant is the transferring of these speed and tractive effort readings to a large chart directly in front of the car being tested. This chart, as can be seen in the illustration, has vertical scales showing the speed in any desired unit and horizontal scales showing the tractive effort in pounds. The cross rulers, giving these indications, are operated by cables, whose movement is controlled by electric motors. These motors are operated through electric contact devices so as to closely follow the movement of the pointer showing the tractive effort and transfer the reading accurately to the large scale, and also from the speed meter to the large scale. This construction is so accurate that the slightest variation in either is instantly followed by change in position of the ruler on the large chart.

The transferring of the record of the speed to the cross ruler on the chart is accomplished by a special apparatus of considerable novelty. This is shown as located in the left foreground of the upper illustration and consists primarily of a cone which is revolved at absolutely constant speed by an electric motor. This speed is verified by a bell attached to the cone shaft, which rings at each 100 revolutions or at intervals of 30 seconds, since the cone revolves at 200 r.p.m. The speed of the dynamometer shaft is transferred by shafts and bevel gears to a shaft parallel to the surface of the cone. A wheel or roller is driven by a light frictional connection to this shaft, being so arranged that it has a free movement along the shaft and tends to revolve at the same speed. The circumference of the wheel, however, rests against the surface of the cone with sufficient pressure to cause it to revolve at the same speed as that particular part of the cone with which it is in contact. This causes a slipping in its connection to the shaft which brings electric contacts into action and starts a small motor. This motor by a cable connection pulls the wheel along the shaft until it finds a point on the cone which will cause it to revolve at the same speed as the shaft. When that condition is attained the motor controlling its movement is held idle, but any change in the speed which will permit a slip in either direction will again put the motor in operation and change the location of the roller to a new position on the cone. The horizontal movement of this wheel is transferred by the same cables to the horizontal ruler on the big chart.



GENERAL VIEW OF AUTOMOBILE DYNAMOMETER SHOWING LARGE CHART.



PENDULUM, FRICTION BRAKE AND APPARATUS BELOW THE FLOOR.

Since horse-power is a function of speed and tractive effort, both of which are shown on the chart, it was a comparatively simple matter to lay out curves showing the different horse-powers for all different conditions, which will permit the instant reading of the horse-power being delivered at the rear wheels by noting the point at which the two moving scales intersect.

The instrument showing the grade which could be climbed at the speed indicated is controlled by the same cables showing the tractive effort on the chart and consists of a pointer fulcrumed at one end and operated from the horizontal cross piece by a clamp which can be set at the proper weight for the car and its occupants. This scale is laid off proportionally to the sine of the angle of the grade, which equals the tractive effort in pounds divided by the weight of the car in pounds, both to the same scale.

A large motor is provided below the floor, which can be thrown on to the driving shaft by means of a clutch, and thus the amount of power required to drive the car with either the engine connected in, which would give the total internal resistance of the car, or thrown out, which would give the resistance for coasting, can be easily read from the chart, as can also the holding power of the brakes.

This dynamometer and all of the electrical apparatus used thereon was built by the Crocker-Wheeler Company.

CUSSING OF NO VALUE.—One thing to remember is that if a man does not know he cannot be cussed into knowing, especially if you have only a short time in which to give him the treatment. A better plan is to wait an opportunity, and not let it pass when it comes, to talk with the man in a quiet and deliberate manner and do your best to give him such help by way of instruction and advice, as will enable him to do better in the future. These are the correct lines to work along and if results cannot be obtained in such a manner better drop the man, as the cussing process sometimes results in embarrassment to the cusser.—*Mr. D. R. MacBain before the Traveling Engineers' Association.*

TIMBER RESOURCES OF OREGON.—It has been estimated that there is sufficient timber, at present standing in the State of Oregon, to build a solid board fence 50 ft. high around the entire United States.

(Established 1832).

AMERICAN ENGINEER AND RAILROAD JOURNAL.

PUBLISHED MONTHLY

BY

R. M. VAN ARSDALE

J. S. BONSALL,
Business Manager.

140 NASSAU STREET, NEW YORK

R. V. WRIGHT, E. A. AVERILL, Editors.

FEBRUARY, 1908

Subscriptions.—*$2.00 a year for the United States and Canada; $2.50 a year to Foreign Countries embraced in the Unversal Postal Union. Remit by Express Money Order, Draft or Post Office Order. Subscription for this paper will be received and copies kept for sale by the Post Office News Co., 217 Dearborn St., Chicago, Ill. Damrell & Upham, 283 Washington St., Boston, Mass. Philip Roeder, 807 North Fourth St., St. Louis, Mo. R. S. Davis & Co., 346 Fifth Ave., Pittsburg, Pa. Century News Co., 6 Third St., S. Minneapolis, Minn. W. Dawson & Sons, Ltd., Cannon St., Bream's Buildings, London, E. C., England.*

Advertisements.—*Nothing will be inserted in this journal for pay,* EXCEPT IN THE ADVERTISING PAGES. *The reading pages will contain only such matter as we consider of interest to our readers.*

Contributions.—*Articles relating to Motive Power Department problems, including the design, construction, maintenance and operation of rolling stock, also of shops and roundhouses and their equipment are desired. Also early notices of official changes, and additions of new equipment for the road or the shop, by purchase or construction.*

To Subscribers.—*The* AMERICAN ENGINEER AND RAILROAD JOURNAL *is mailed regularly to every subscriber each month. Any subscriber who fails to receive his paper ought at once to notify the postmaster at the office of delivery, and in case the paper is not then obtained this office should be notified, so that the missing paper may be supplied.*

When a Subscriber changes his address *he should notify this office at once, so that the paper may be sent to the proper destination.*

CONTENTS

FEED WATER HEATERS.

We are informed, on seemingly good authority, that locomotive feed water heaters on the Egyptian State Railways save 20 per cent. of the fuel. (Why it is that any device for improving locomotive performance, which seems to have some merit, is always claimed to save 20 per cent. is more than we can explain.) There is no doubt in anyone's mind but what a considerable saving, as such things are usually figured, can be made by the heating of the feed water injected into a locomotive boiler to 250 degrees or more. As to the net saving, or in other words, whether the game is worth the candle or not, is another question and one which it is hard to decide until the game has been tried. Furthermore, a decision on one road or in one section with a certain arrangement would not necessarily apply to the whole country or to the value of the principle. It is the same with this as with all other improvements on railways, that it is the net savings obtained in regular daily service covering a long period of time and with the operating force ready to give it a black eye, if possible, which must decide its existence. It won't do to save a ton of coal worth $2.00 if it is going to take three men three hours at 75 cents an hour to keep it in condition to do it.

We believe that a feed water heater can be designed which will show a very considerable net saving and that the possibilities are large enough and bright enough to make it worth while giving it a fair trial. Two or three companies are now engaged in such trials, notably the Central of Georgia Railway, whose heater is illustrated on page 71, and it is probable that within six months or a year data will be available which will give some indication of what may be expected to be the future of the idea in at least certain sections of this country.

SUGGESTIONS FOR SHOP VISITS.

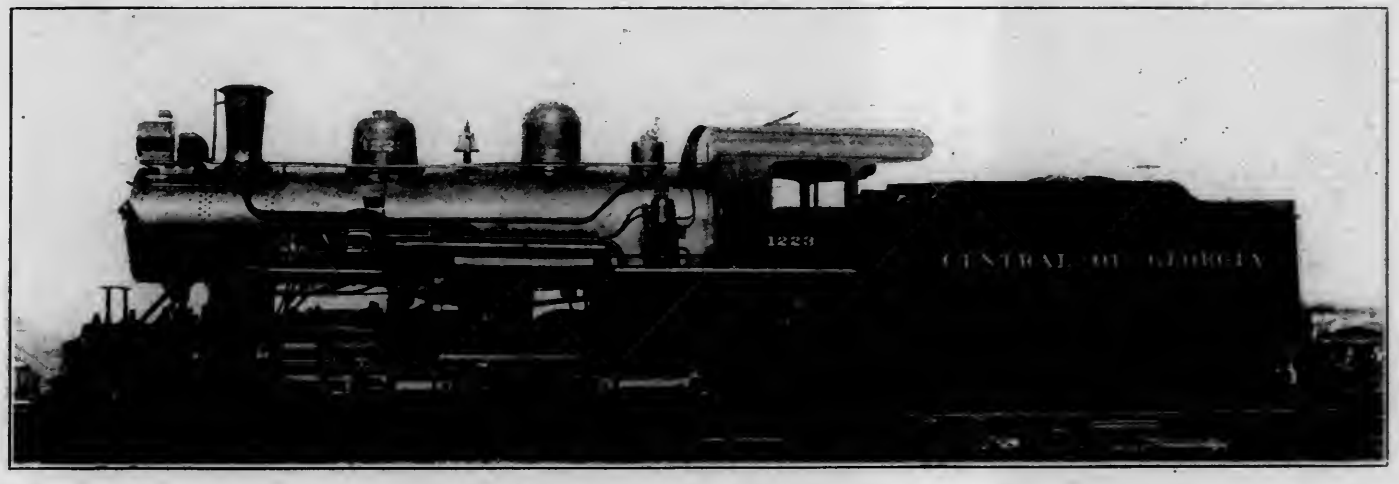
A superintendent of motive power called his master mechanics and shop superintendents together for consultation at a large railroad center. When the business in hand had been finished the suggestion was made that the party visit a large shop plant of a neighboring railroad and spend half a day in looking over it. This was agreed to, but undoubtedly comparatively little good would have come of it had it not been that the superintendent of motive power assigned a special topic for each man to investigate and to report upon. Instead of wandering aimlessly through the shop in a large group the members, on arriving at the shop, immediately started out to find out all that they could about the part of the work which they were detailed to study. As a result the superintendent of motive power had on his desk a few days later a dozen carefully prepared reports on different subjects in which he was specially interested. Copies of all of the reports were sent to each member of the party and were instrumental in starting several important improvements.

ORGANIZATION IN FREIGHT CAR SHOPS.

The freight car building department of the Canadian Pacific Railway at the Angus shops, Montreal, is doing splendid work, as may be seen from the article in this issue. The plant is well arranged; the buildings are large and well lighted; the equipment is good and is kept in a good state of repair; but most important of all it has an exceedingly good organization and the work in all departments is highly specialized.

There are some new shops with buildings and equipment just as good and well arranged, but results are lacking because of a poor organization. On the other hand, there are old and poorly arranged shops with only fair equipment, and yet comparatively good results are being obtained because of a good organization and the fact that little and apparently unimportant facilities have been gathered together in the different departments, which taken together do much to offset the better tools that are used in other shops which are new and about which only a few special tools and conveniences have as yet been gathered.

It is not often that such a good all-around combination is found as at the Angus shops. Of course, only new work is done in the freight car department and this simplifies the problem greatly. Manufacturers often smile in a patronizing way at the methods used in the mechanical departments of the railroads, but in this case, where conditions are comparable with those of the manufacturing concerns, the railroad company certainly does not have to make any apologies.



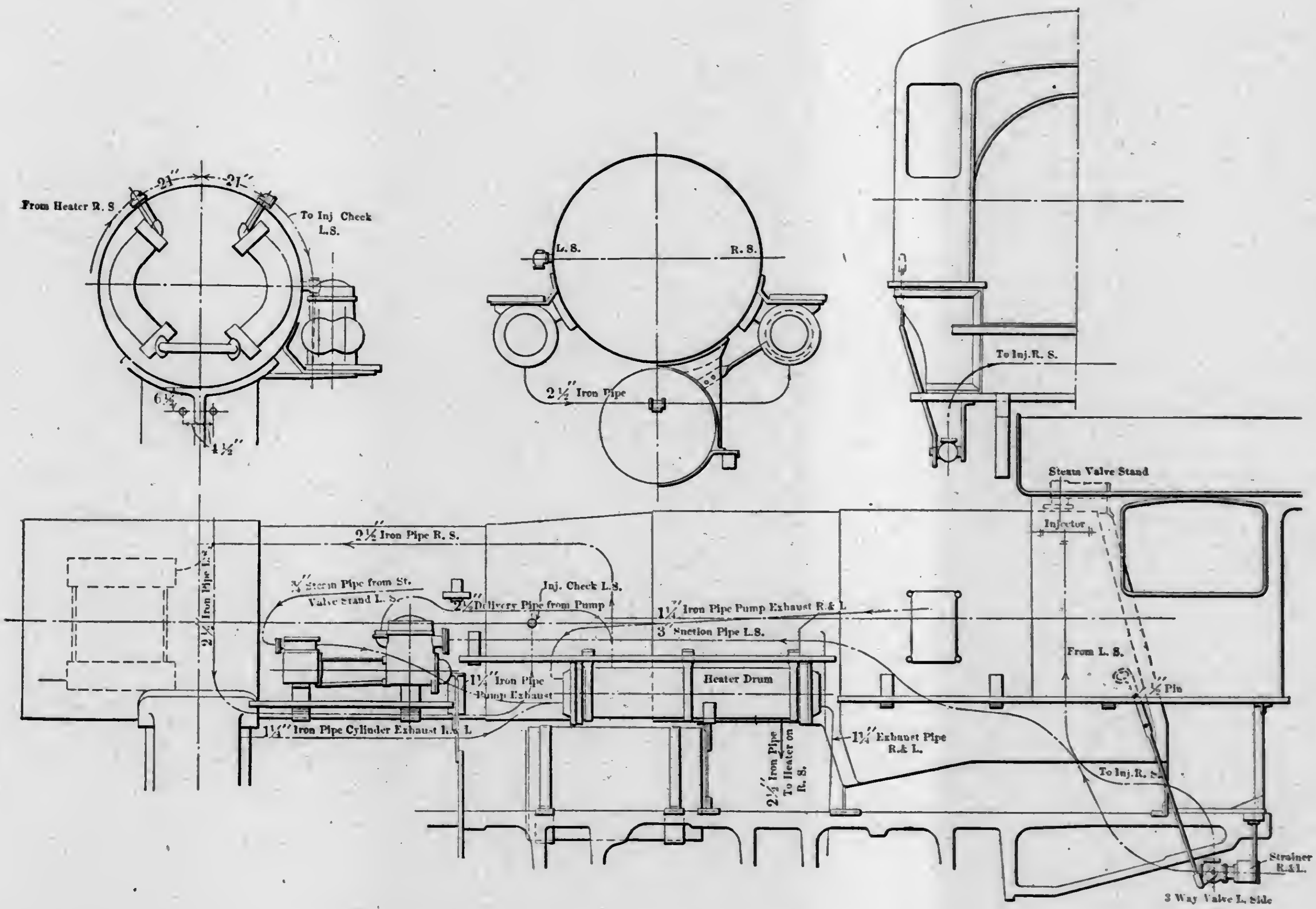
CONSOLIDATION LOCOMOTIVE WITH FEED WATER HEATER—CENTRAL OF GEORGIA RAILWAY.

LOCOMOTIVE FEED WATER HEATER.

CENTRAL OF GEORGIA RAILWAY.

It is generally admitted, by those who have made a study of the subject, that the enormous internal strains caused by the injection of comparatively cold water into a locomotive boiler are responsible for a large part of the universal difficulty that has been experienced with keeping the modern large sized locomotive boilers from leaking. Experiments with devices for more thoroughly mixing the entering supply with the water already in the boiler have resulted in much improvement in this respect, but it is easily understood that to completely overcome trouble it would be simply a matter of heating the feed water to a temperature approximately that of the water already in the boiler, so that when it is admitted there will be but a slight difference in temperature and no local distortion in the plates. It is also easy to understand that whatever heat is put into the feed water before it enters the boiler will not have to be provided later from the fire-box. This, of course, provided the heat is obtained from waste sources, results in either less coal required to furnish the same amount of steam, or a larger boiler capacity with the same amount of coal burned.

These advantages have been given more practical attention in those countries where the cost of fuel is very high, and where any device seeming to insure fuel economy has always been given



LOCOMOTIVE FEED WATER HEATER SHOWING COURSE FOLLOWED BY THE WATER.

(Established 1832).

AMERICAN ENGINEER AND RAILROAD JOURNAL.

PUBLISHED MONTHLY

BY

R. M. VAN ARSDALE

J. S. BONSALL,
Business Manager.

140 NASSAU STREET, NEW YORK

R. V. WRIGHT, E. A. AVERILL, Editors.

FEBRUARY, 1908

Subscriptions.—*$2.00 a year for the United States and Canada; $2.50 a year to Foreign Countries embraced in the Universal Postal Union. Remit by Express Money Order, Draft or Post Office Order. Subscription for this paper will be received and copies kept for sale by the*
Post Office News Co., 217 Dearborn St., Chicago, Ill.
Damrell & Upham, 283 Washington St., Boston, Mass.
Philip Roeder, 307 North Fourth St., St. Louis, Mo.
R. S. Davis & Co., 346 Fifth Ave., Pittsburg, Pa.
Century News Co., 6 Third St., S. Minneapolis, Minn.
W. Dawson & Sons, Ltd., Cannon St., Bream's Buildings, London, E. C., England.

Advertisements.—*Nothing will be inserted in this journal for pay,* EXCEPT IN THE ADVERTISING PAGES. *The reading pages will contain only such matter as we consider of interest to our readers.*

Contributions.—*Articles relating to Motive Power Department problems, including the design, construction, maintenance and operation of rolling stock, also of shops and roundhouses and their equipment are desired. Also early notices of official changes, and additions of new equipment for the road or the shop, by purchase or construction.*

To Subscribers.—*The* AMERICAN ENGINEER AND RAILROAD JOURNAL *is mailed regularly to every subscriber each month. Any subscriber who fails to receive his paper ought at once to notify the postmaster at the office of delivery, and in case the paper is not then obtained this office should be notified, so that the missing paper may be supplied.*

When a Subscriber changes his address *he should notify this office at once, so that the paper may be sent to the proper destination.*

CONTENTS

FEED WATER HEATERS.

We are informed, on seemingly good authority, that locomotive feed water heaters on the Egyptian State Railways save 20 per cent. of the fuel. (Why it is that any device for improving locomotive performance, which seems to have some merit, is always claimed to save 20 per cent. is more than we can explain.) There is no doubt in anyone's mind but what a considerable saving, as such things are usually figured, can be made by the heating of the feed water injected into a locomotive boiler to 250 degrees or more. As to the net saving, or in other words, whether the game is worth the candle or not, is another question and one which it is hard to decide until the game has been tried. Furthermore, a decision on one road or in one section with a certain arrangement would not necessarily apply to the whole country or to the value of the principle. It is the same with this as with all other improvements on railways, that it is the net savings obtained in regular daily service covering a long period of time and with the operating force ready to give it a black eye, if possible, which must decide its existence. It won't do to save a ton of coal worth $2.00 if it is going to take three men three hours at 75 cents an hour to keep it in condition to do it.

We believe that a feed water heater can be designed which will show a very considerable net saving and that the possibilities are large enough and bright enough to make it worth while giving it a fair trial. Two or three companies are now engaged in such trials, notably the Central of Georgia Railway, whose heater is illustrated on page 71, and it is probable that within six months or a year data will be available which will give some indication of what may be expected to be the future of the idea in at least certain sections of this country.

SUGGESTIONS FOR SHOP VISITS.

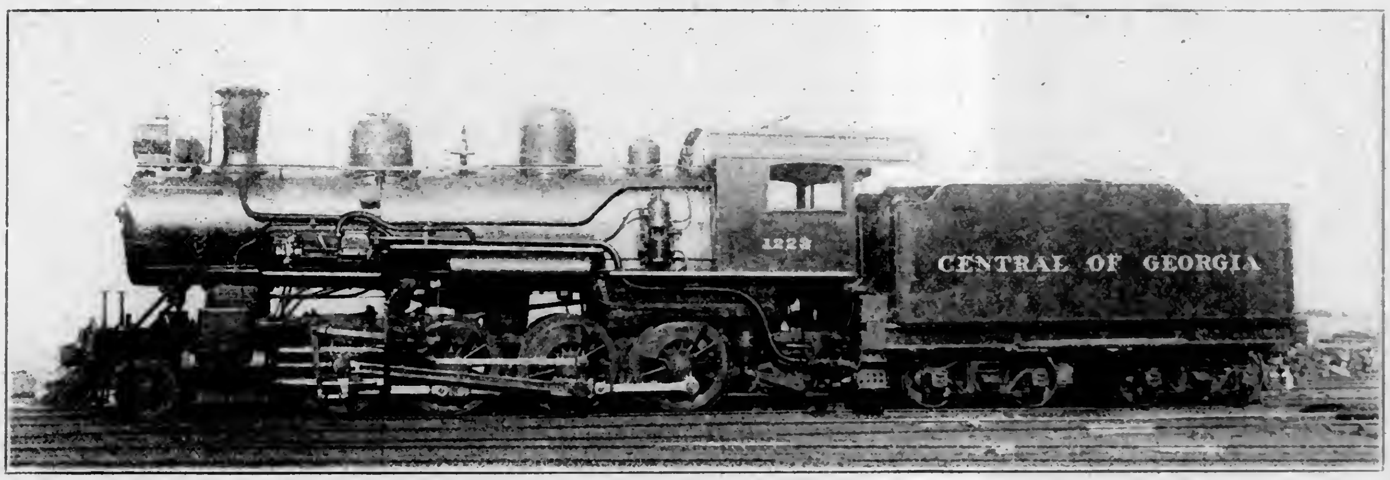
A superintendent of motive power called his master mechanics and shop superintendents together for consultation at a large railroad center. When the business in hand had been finished the suggestion was made that the party visit a large shop plant of a neighboring railroad and spend half a day in looking over it. This was agreed to, but undoubtedly comparatively little good would have come of it had it not been that the superintendent of motive power assigned a special topic for each man to investigate and to report upon. Instead of wandering aimlessly through the shop in a large group the members, on arriving at the shop, immediately started out to find out all that they could about the part of the work which they were detailed to study. As a result the superintendent of motive power had on his desk a few days later a dozen carefully prepared reports on different subjects in which he was specially interested. Copies of all of the reports were sent to each member of the party and were instrumental in starting several important improvements.

ORGANIZATION IN FREIGHT CAR SHOPS.

The freight car building department of the Canadian Pacific Railway at the Angus shops, Montreal, is doing splendid work, as may be seen from the article in this issue. The plant is well arranged; the buildings are large and well lighted; the equipment is good and is kept in a good state of repair; but most important of all it has an exceedingly good organization and the work in all departments is highly specialized.

There are some new shops with buildings and equipment just as good and well arranged, but results are lacking because of a poor organization. On the other hand, there are old and poorly arranged shops with only fair equipment, and yet comparatively good results are being obtained because of a good organization and the fact that little and apparently unimportant facilities have been gathered together in the different departments, which taken together do much to offset the better tools that are used in other shops which are new and about which only a few special tools and conveniences have as yet been gathered.

It is not often that such a good all-around combination is found as at the Angus shops. Of course, only new work is done in the freight car department and this simplifies the problem greatly. Manufacturers often smile in a patronizing way at the methods used in the mechanical departments of the railroads, but in this case, where conditions are comparable with those of the manufacturing concerns, the railroad company certainly does not have to make any apologies.



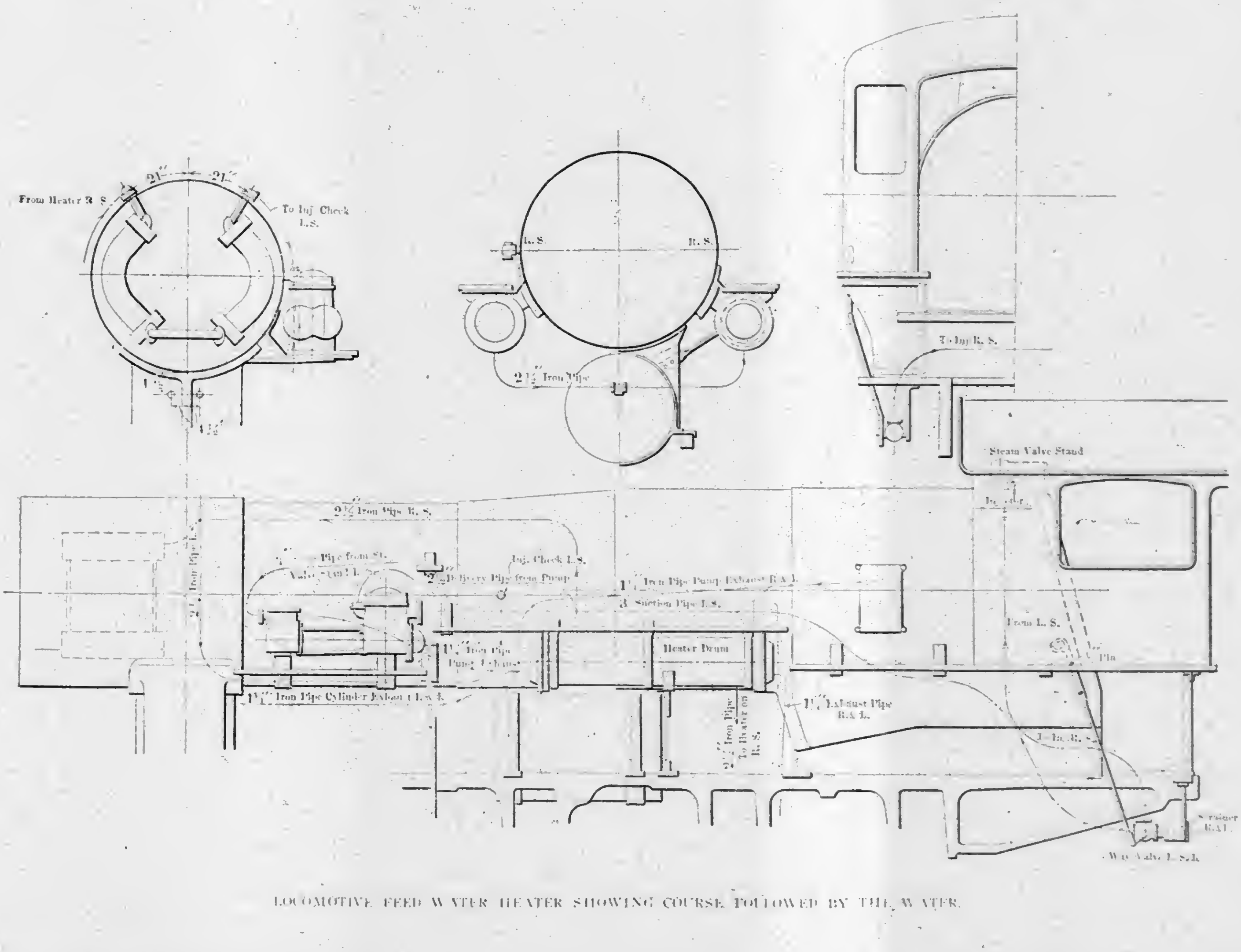
CONSOLIDATION LOCOMOTIVE WITH FEED WATER HEATER—CENTRAL OF GEORGIA RAILWAY.

LOCOMOTIVE FEED WATER HEATER.

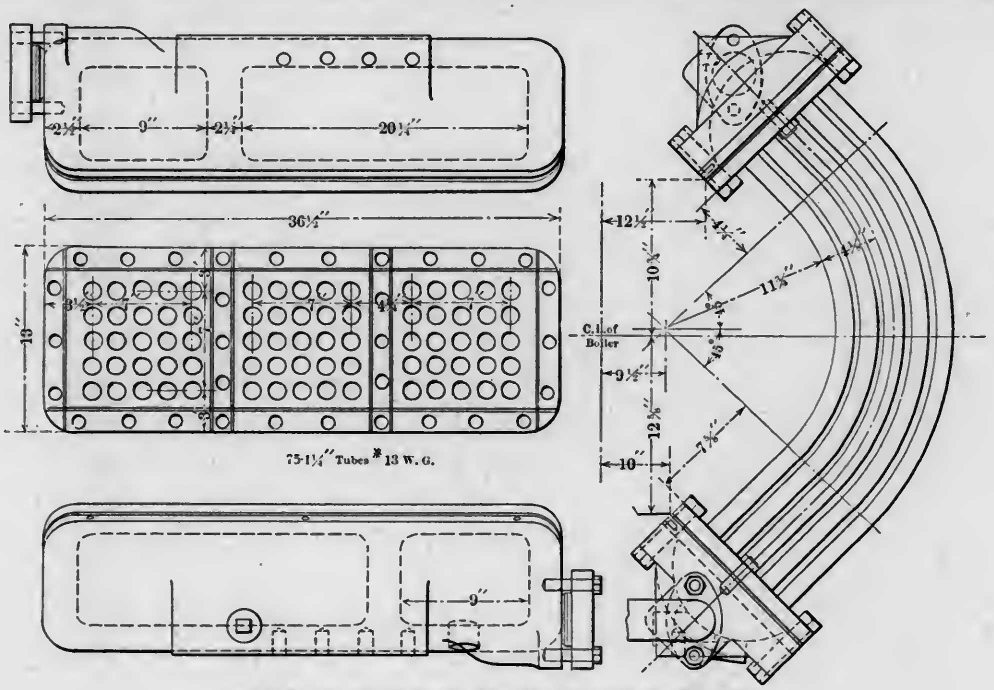
CENTRAL OF GEORGIA RAILWAY.

It is generally admitted, by those who have made a study of the subject, that the enormous internal strains caused by the injection of comparatively cold water into a locomotive boiler are responsible for a large part of the universal difficulty that has been experienced with keeping the modern large sized locomotive boilers from leaking. Experiments with devices for more thoroughly mixing the entering supply with the water already in the boiler have resulted in much improvement in this respect, but it is easily understood that to completely overcome trouble it would be simply a matter of heating the feed water to a temperature approximately that of the water already in the boiler, so that when it is admitted there will be but a slight difference in temperature and no local distortion in the plates. It is also easy to understand that whatever heat is put into the feed water before it enters the boiler will not have to be provided later from the fire-box. This, of course, provided the heat is obtained from waste sources, results in either less coal required to furnish the same amount of steam, or a larger boiler capacity with the same amount of coal burned.

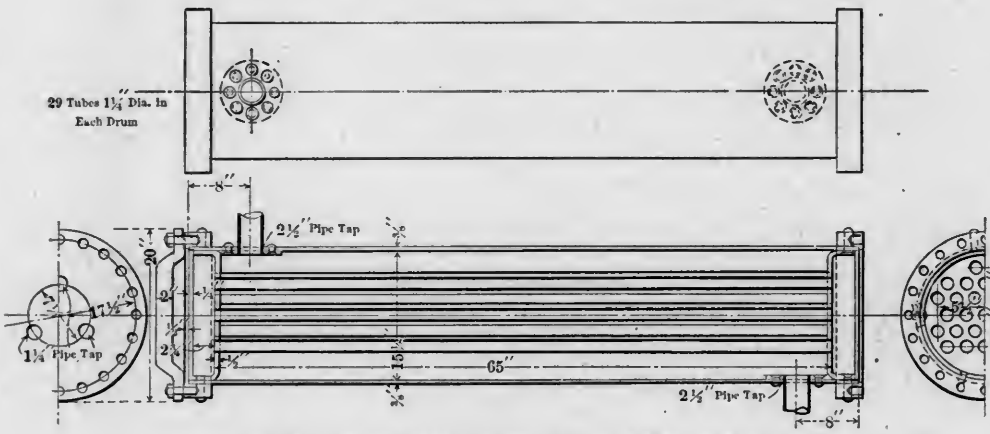
These advantages have been given more practical attention in those countries where the cost of fuel is very high, and where any device seeming to insure fuel economy has always been given



LOCOMOTIVE FEED WATER HEATER SHOWING COURSE FOLLOWED BY THE WATER.



DETAILS OF SECTION OF HEATER IN THE FRONT END.



DETAILS OF HEATERS UNDER THE RUNNING BOARDS.

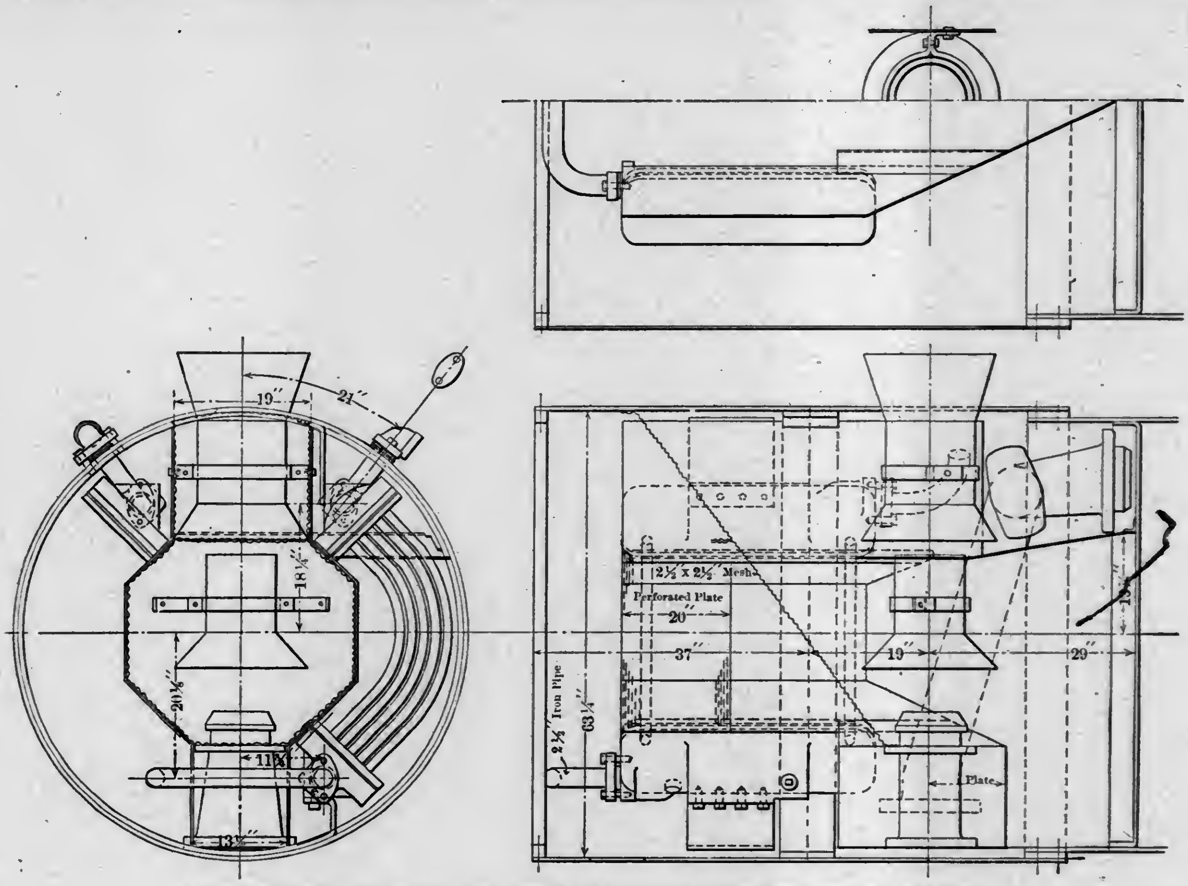
most careful attention and thorough testing than they have in this country, and feed water heaters of various designs have been successfully fitted to a large number of foreign locomotives. One of the most successful of these was applied by Mr. Trevithick, locomotive superintendent of the Egyptian State Railways, whose design was illustrated on page 436 of the November, 1907, issue of this journal. An economy of approximately 20 per cent. is reported by the use of that heater.

One of the first attempts to develop the capabilities of real feed water heating, under American conditions, is now being made by Mr. F. F. Gaines, superintendent of motive power of the Central of Georgia Railway, who has recently received a consolidation locomotive from the Baldwin Locomotive Works fitted with a heater of his design, which in principle follows that so successfully installed by Mr. Trevithick.

The constructional features of this heater are shown in the illustrations and in brief it consists of first, a duplex, horizontal, feed pump, which delivers the water to two heater drums secured beneath the running boards, one on either side, and connected in series. These drums are filled with small tubes through the interior of which exhaust steam from the feed and air pumps and also some from the exhaust passage of the cylinders is passed. The feed water circulates around the outside of the tubes and absorbs the heat from this steam. It then passes to a heater in the front end, which is designed along the same lines as is used by the Baldwin superheater. After traversing a path approximately 25 ft. long through these tubes and heaters, in which it absorbs the heat from the front end gases, a deflector plate being provided to compel them to pass around the tubes before going to the stack, it is delivered to the boiler check valve located in the usual position on the left-hand side.

The water passing through the different heaters is driven at a very low velocity, not exceeding 16 ft. per minute, and hence is given ample opportunity to absorb large amounts of heat. Although tests have not yet been completed to show exactly what temperature is attained at each stage, it is fair to assume from the figures obtained by Mr. Trevithick that the water will probably be delivered to the boiler at something over 300 degrees. (Water or steam at 200 lbs. pressure has a temperature of 387.5 degrees.)

The greatest objection which can be offered to a heater of this design is the trouble which would be experienced in the depositing of all of the incrusting matter in the feed water upon the tubes of the various heaters, so that they would soon become seriously clogged up and make the arrangement useless. We are advised, however, that this difficulty has been considered in connection with designing this heater and that the locomotive is to be used in service where the water contains little hard scale forming impurities. Since the temperature in the various heaters is comparatively low there will be no tendency for this scale to bake on and it can no doubt be easily washed out. Washout plugs have been provided in the side heaters and the lower drums of the front end heater. However, under conditions where bad water would have to be used the heater could be so re-designed as to permit that section in which the largest part of the incrusting matter was thrown down to be removed and cleaned, which would thus give the heater a very large advantage because of its ability to keep these impurities out of the boiler itself.



ARRANGEMENT OF FRONT END APPARATUS—LOCOMOTIVE FEED WATER HEATER.

The locomotive to which this heater is fitted has the following general dimensions:

GENERAL DATA.	
Gauge	4 ft. 8½ in.
Service	Freight
Fuel	Bit. coal
Tractive effort	34,000 lbs.
Weight in working order	168,200 lbs.
Weight on drivers	150,500 lbs.
Weight on leading truck	17,700 lbs.
Weight of engine and tender in working order	288,000 lbs.
Wheel base, driving	16 ft.
CYLINDERS.	
Kind	Simple
Diameter and stroke	20 x 28 in.
Kind of valves	Bal. slide
WHEELS.	
Driving, diameter over tires	56 in.
Driving journals, diameter and length	8½ x 10 in.
BOILER.	
Style	E. W. T.
Working pressure	200 lbs.
Outside diameter of first ring	61 in.
Firebox, length and width	96⅛ x 66 in.
Firebox water space	F.—4, S. & B.—3 in.
Tubes, number and outside diameter	283—2 in.
Tubes, length	14 ft. 8 in.
Heating surface, tubes	2,161 sq. ft.
Heating surface, firebox	146 sq. ft.
Heating surface, total	2,307 sq. ft.
Grate area	44 sq. ft.
TENDER.	
Water capacity	6,000 gals.
Coal capacity	8 tons

CARS AND LOCOMOTIVES BUILT IN 1907.

The total number of railroad cars built in the United States and Canada during the year 1907 was 289,645, an increase of 19 per cent. over the record-breaking output of the previous year. This includes subway and elevated cars, but does not include electric street or interurban cars. Of the total number of cars built by manufacturers 284,188 were for freight service and 280,216 of the total were for domestic use. The number of passenger cars is an increase of more than 70 per cent. over the previous year. About 72 per cent. of the freight cars built were of steel or steel underframe construction. Canada built 9,159 freight cars and 106 passenger cars. None of these figures include the cars built by railroad companies in their own shops. The total number of cars built in the U. S. and Canada in 1905 was 168,006 and in 1906 was 243,670.

The twelve locomotive builders in the U. S. and Canada built 7,362 locomotives during the year, of which 798 were for export. This is an increase of 6 per cent. in the total output. There were 330 electric locomotives and 240 compound locomotives built during the year. The Canadian output was 264. The figures for the total number of locomotives built in the U. S. and Canada for the year 1905 was 5,491 and for 1906 was 6,952.

The total amount spent by the railroads for new rolling stock approximates $477,000,000, an increase of about 25 per cent. over the previous year.—*Railroad Gazette.*

SHRINKAGE OF WOOD WHEN DRIED.

Interesting experiments on the shrinkage of wood due to the loss of moisture have recently been completed by the Forest Service at its timber testing station at Yale University. These experiments show that green wood does not shrink at all in drying until the amount of moisture in it has been reduced to about one-third of the dry weight of the wood. From this point on to the absolutely dry condition, the shrinkage in the area of cross-section of the wood is directly proportional to the amount of moisture removed.

The shrinkage of wood in a direction parallel to the grain is very small; so small in comparison with the shrinkage at right angles to the grain, that in computing the total shrinkage in volume, the longitudinal shrinkage may be neglected entirely. The volumetric shrinkage varies with different woods, being about 26 per cent. of the dry volume for the species of eucalyptus known as blue gum, and only about 7 per cent. for red cedar. For hickory, the shrinkage is about 20 per cent. of the dry volume, and for longleaf pine about 15 per cent. In the usual air dry condition from 12 to 15 per cent. of moisture still remains in the wood, so that the shrinkage from the green condition to the air dry condition is only a trifle over half of that from the green to the absolutely dry state.

RAILWAY STOREKEEPERS' ASSOCIATION.—The fifth annual meeting will be held at the Auditorium Hotel, Chicago, May 25, 26 and 27, 1908.

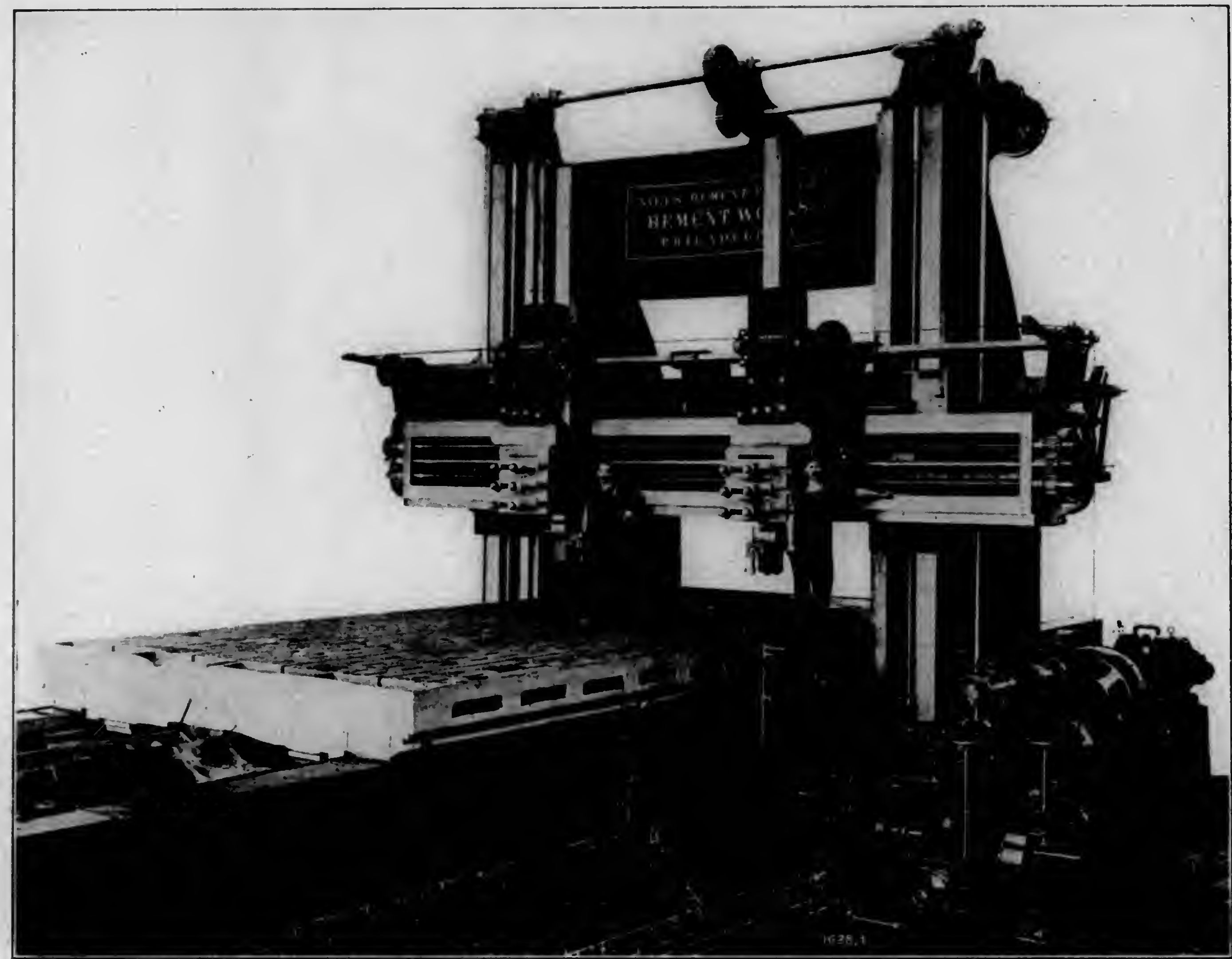


FIG. 1.—$422\frac{1}{2}$ TON PLANER. NILES-BEMENT-POND COMPANY.

THE LARGEST PLANER.

The McKintosh-Hemphill Company, of Pittsburgh, Pa., has recently received from the Bement Works, of the Niles-Bement Pond Company, what is believed to be the largest planer ever built.

Its total weight is 845,000 lbs., and four motors with a total capacity of $207\frac{1}{2}$ h.p. are required to operate it. In addition to the movements found on a standard machine, many new ones have been added.

Each head is fitted with a slotter bar independently driven by a rack, giving a practically constant cutting speed from one end of the stroke to the other, and a quick return. Each head is arranged for transverse planing, having a movement across the bed. These movements for slotting and transverse planing make it necessary to throw out the regular driving mechanism to the table and connect it to a separate feed motion, entirely distinct from the regular feed motion. This throwing out of the driving mechanism means simply that the pneumatic driving clutches are thrown into and left in their idle position.

The machine is fitted with its own air compressor and motor, thus making it independent of the air supply in the shop, to which, however, it can be connected if it seems desirable. A complete switchboard is furnished for the control of all the motors.

The distance between uprights is 14 ft. 4 in.; the maximum distance from the table to the bottom of the cross slide is 12 ft. 2 in.; the maximum stroke of the table is 30 ft.; maximum stroke of the slotter bar is 8 ft.; total width of the bed 13 ft.; length of the bed, 60 ft.; table ways, 15 in. each in width; tool slides, 7 ft. 8 in., with 4 ft. vertical traverse; cross rail is long enough to admit full traverse of either head between the posts; face of uprights, 2 ft. 6 in.; vertical height of cross slide, including the top rib bracing is 5 ft. The main driving motor is 100 h.p.; slotting and cross planing motor is 50 h.p.; lifting motor to cross slide, 20 h.p.; traverse motor for heads on cross slide, $7\frac{1}{2}$ h.p.; air compressor motor, 30 h.p.

The cutting and return speeds are variable through the motor, which has a 1 to $1\frac{1}{4}$ variation, and by change gears. The cutting speeds are 14 to 25 ft. and return speeds $52\frac{1}{2}$ to $65\frac{1}{2}$ ft. The same type of drive is used for the slotters and gives a cutting speed of $18\frac{1}{2}$ to 30 ft. and return speed of 57 to 71 ft. Cutting speed for cross planing is $11\frac{1}{2}$ to 19 ft. and return speed 35 to $43\frac{1}{2}$ ft. The cross traverse speed to the heads is 50 in. per minute; the vertical speed for raising and lowering the cross slide is 26 in. per minute.

The main drive from the 100 h.p. motor is clearly shown in Figs. 1 and 3. The speed of the pneumatic reversing clutches may be varied to some extent by changing the speed or the motor, and a greater variation may be obtained by the simple reversing of two change gears. The pneumatic clutches which are shown thoroughly incased are of the Niles-Bement-Pond type with a large number of friction discs, whereby great friction area is obtained in a comparatively small compass. These clutches are operated by compressed air. A small valve, easily moved by hand, controls the stopping, starting and reversing of the table and handles satisfactorily the power given out by the large driving motor. From this point to the rack the drive is, in practically every respect, that which is found on any planer, except, of course, in this instance, it is exceptionally heavy and powerful. The two bull pinions are forged directly on the shaft, being cut half pitch apart, in order to give smoothness of motion.

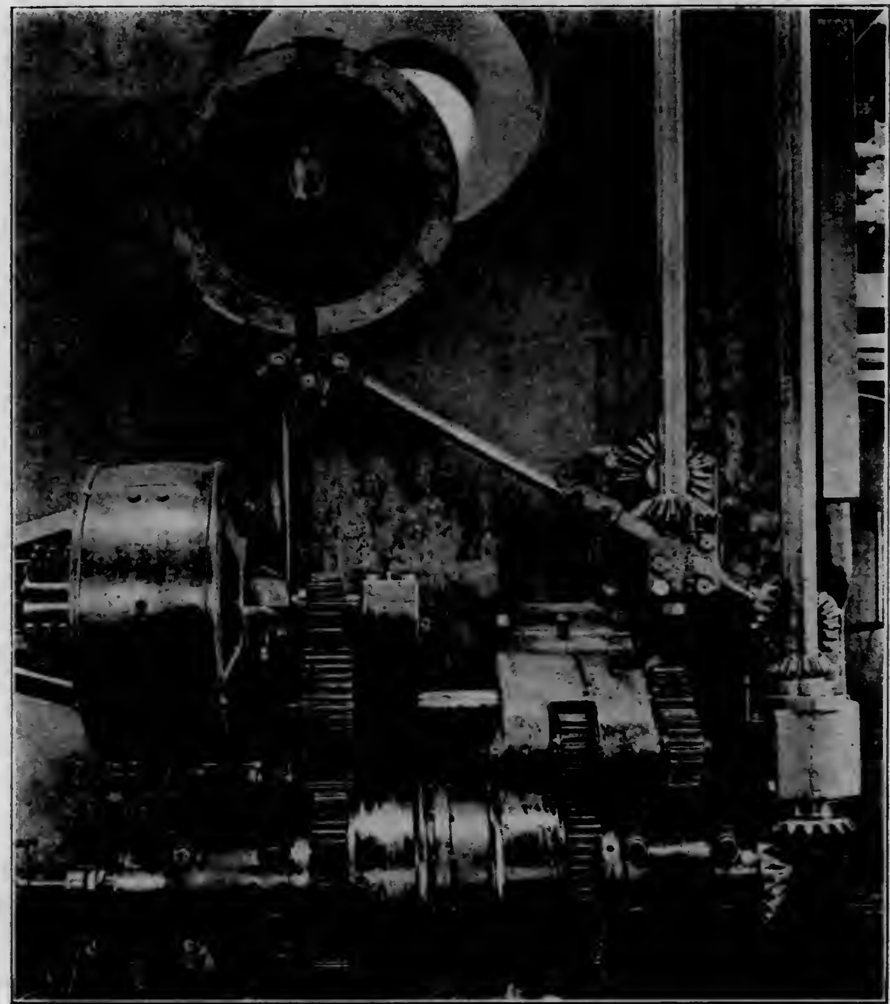


FIG. 2.—DRIVE FOR THE SLOTTER ATTACHMENTS.

An interesting feature is the pneumatic feed. The feed for the cross heads is clearly shown in Fig. 3. On the side of the upright just above the gearing is a cylinder with a piston rod extending to the left. This rod carries a rack which meshes into a gear near the bottom of the vertical feed shaft. This shaft has on its lower end, a bevel gear meshing into another bevel gear on a horizontal shaft, which transmits motion to the vertical feed shaft on the left-hand upright. The movement of these feed shafts is constant at all times and variation in amount and direction of head feeds is obtained by adjusting the connecting rod in the slotted cranks on the ends of the cross slide. These cranks are graduated in such a way that definite cross and vertical feeds can be obtained, and by using at the same time the cranks on both sides an angular feed can be given to the tool, which is at times desirable, as the heads were not designed to swivel. The valve for controlling the air to the feed cylinder is thrown automatically at each end of the stroke, this movement being taken from either the main driving gear train to the table, or the slotter gearing, when slotting is being done. To throw out the feed, it is simply necessary to close a valve, cutting off the air supply.

The feed for the table, when slotting or transverse planing is being done, had not yet been placed in position when the photo, Fig. 3, was taken, but it is shown in Fig. 1, directly in front of and at the base of the upright. This feed operates practically the same as the feed for the cross head previously described,except that variation in stroke or amount of feed is obtained by an adjustable stop which regulates the amount of movement of the piston in the cylinder. This adjustment is made by the right-hand hand-wheel; the left-hand hand-wheel is for connecting and disconnecting the feed mechanism to the main driving works.

The slotter drive is shown in detail in Fig. 2. The description of the main drive on the opposite upright fits this one up to and including the pneumaitc clutches. For the main drive, the power is then carried through the upright into the bed while for the slotter drive it is transmitted to the vertical square shaft and thence by bevels and spur gearing to the horizontal square shaft running along the top of the cross slide. The pinion of this shaft drives the large gear, of which only the cover can be seen. The rack pinion which gears into the back of the cutter bar is on the same shaft with this gear. The pinion on the square shaft slides and can be thrown in or out of gear as desired, so that either or both bars can be used. The disc shown just above the motor controls the length of stroke. This disc is driven from the main train of slotter gearing and the adjustable stops on its periphery can be set at any desired point and effect the reversal in the same way as do dogs on the side of a planer table. Near the bottom of the square vertical shaft may be seen the bevel gear on the end of a horizontal shaft, which goes across the bed and can be connected to the mechanism operating the valve of the feed cylinder on the opposite side, as mentioned in the description of the feed for the heads.

In Figs. 1 and 3 can be seen a vertical shaft where the reversing hand lever of a standard planer is usually found; it will be

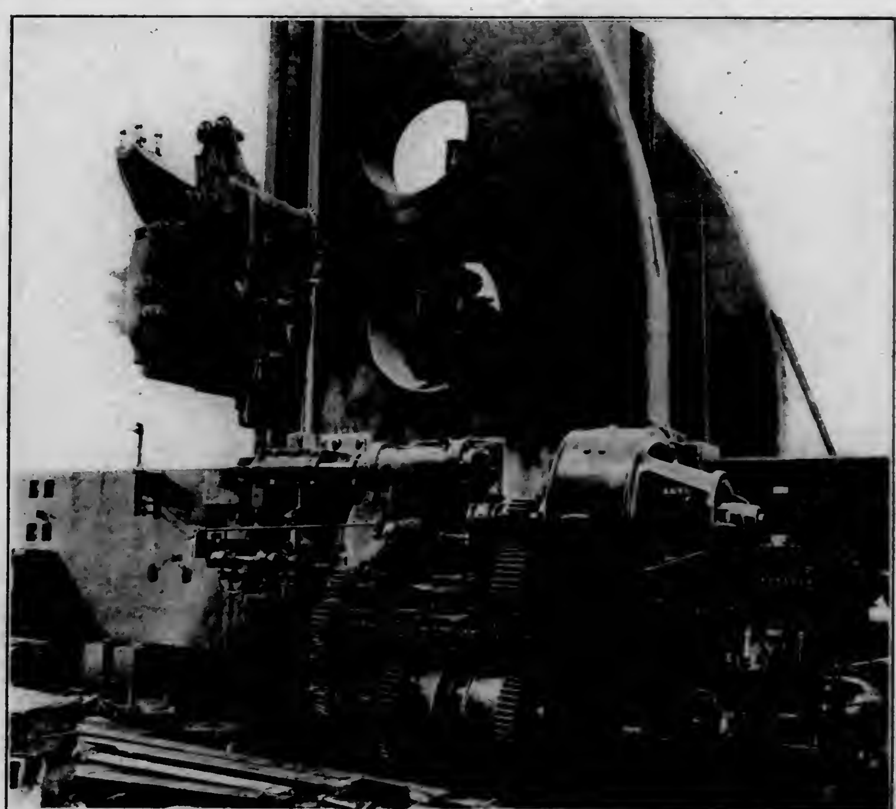


FIG. 3.—SIDE VIEW SHOWING THE MAIN DRIVE.

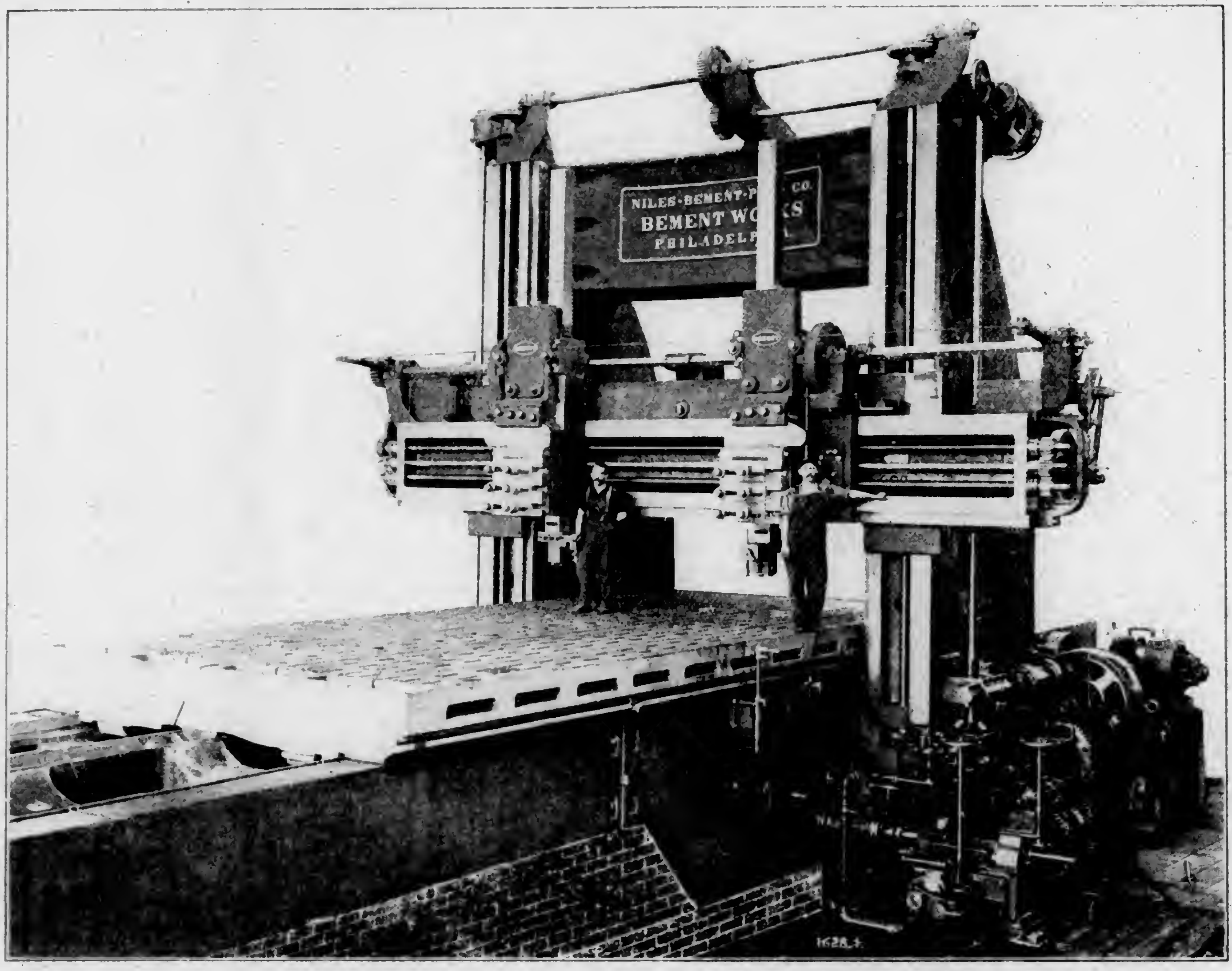


FIG. 1.—422½ TON PLANER. NILES-BEMENT-POND COMPANY.

THE LARGEST PLANER.

The McKintosh-Hemphill Company, of Pittsburgh, Pa., has recently received from the Bement Works, of the Niles-Bement Pond Company, what is believed to be the largest planer ever built.

Its total weight is 845,000 lbs., and four motors with a total capacity of 207½ h.p. are required to operate it. In addition to the movements found on a standard machine, many new ones have been added.

Each head is fitted with a slotter bar independently driven by a rack, giving a practically constant cutting speed from one end of the stroke to the other, and a quick return. Each head is arranged for transverse planing, having a movement across the bed. These movements for slotting and transverse planing make it necessary to throw out the regular driving mechanism to the table and connect it to a separate feed motion, entirely distinct from the regular feed motion. This throwing out of the driving mechanism means simply that the pneumatic driving clutches are thrown into and left in their idle position.

The machine is fitted with its own air compressor and motor, thus making it independent of the air supply in the shop, to which, however, it can be connected if it seems desirable. A complete switchboard is furnished for the control of all the motors.

The distance between uprights is 14 ft. 4 in.; the maximum distance from the table to the bottom of the cross slide is 12 ft. 2 in.; the maximum stroke of the table is 30 ft.; maximum stroke of the slotter bar is 8 ft.; total width of the bed 13 ft.; length of the bed, 60 ft.; table ways, 15 in. each in width; tool slides, 7 ft. 8 in., with 4 ft. vertical traverse; cross rail is long enough to admit full traverse of either head between the posts; face of uprights, 2 ft. 6 in.; vertical height of cross slide, including the top rib bracing is 5 ft. The main driving motor is 100 h.p.; slotting and cross planing motor is 50 h.p.; lifting motor to cross slide, 20 h.p.; traverse motor for heads on cross slide, 7½ h.p.; air compressor motor, 30 h.p.

The cutting and return speeds are variable through the motor, which has a 1 to 1¼ variation, and by change gears. The cutting speeds are 14 to 25 ft. and return speeds 52½ to 65½ ft. The same type of drive is used for the slotters and gives a cutting speed of 18½ to 30 ft. and return speed of 57 to 71 ft. Cutting speed for cross planing is 11½ to 19 ft. and return speed 35 to 43½ ft. The cross traverse speed to the heads is 50 in. per minute; the vertical speed for raising and lowering the cross slide is 26 in. per minute.

The main drive from the 100 h.p. motor is clearly shown in Figs. 1 and 3. The speed of the pneumatic reversing clutches may be varied to some extent by changing the speed of the motor, and a greater variation may be obtained by the simple reversing of two change gears. The pneumatic clutches which are shown thoroughly incased are of the Niles-Bement-Pond type with a large number of friction discs, whereby great friction area is obtained in a comparatively small compass. These clutches are operated by compressed air. A small valve, easily moved by hand, controls the stopping, starting and reversing of the table and handles satisfactorily the power given out by the large driving motor. From this point to the rack the drive is, in practically every respect, that which is found on any planer, except, of course, in this instance, it is exceptionally heavy and powerful. The two bull pinions are forged directly on the shaft, being cut half pitch apart, in order to give smoothness of motion.

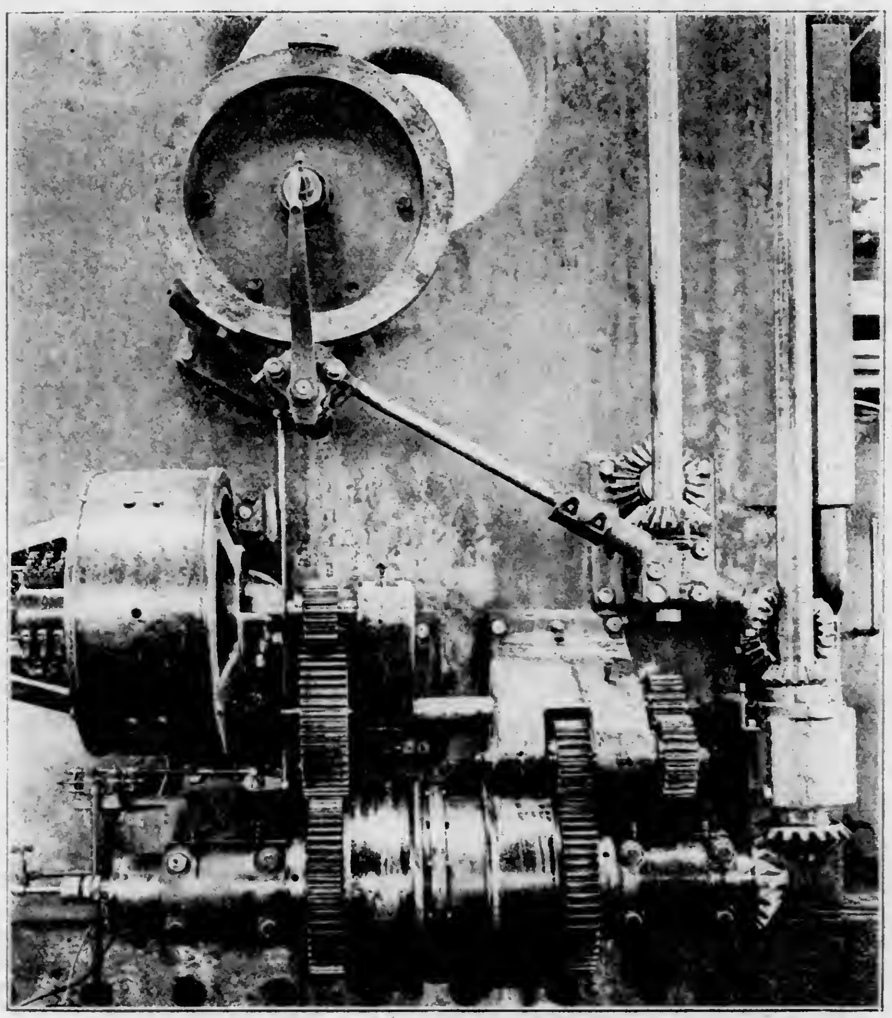


FIG. 2.—DRIVE FOR THE SLOTTER ATTACHMENTS.

An interesting feature is the pneumatic feed. The feed for the cross heads is clearly shown in Fig. 3. On the side of the upright just above the gearing is a cylinder with a piston rod extending to the left. This rod carries a rack which meshes into a gear near the bottom of the vertical feed shaft. This shaft has on its lower end, a bevel gear meshing into another bevel gear on a horizontal shaft, which transmits motion to the vertical feed shaft on the left-hand upright. The movement of these feed shafts is constant at all times and variation in amount and direction of head feeds is obtained by adjusting the connecting rod in the slotted cranks on the ends of the cross slide. These cranks are graduated in such a way that definite cross and vertical feeds can be obtained, and by using at the same time the cranks on both sides an angular feed can be given to the tool, which is at times desirable, as the heads were not designed to swivel. The valve for controlling the air to the feed cylinder is thrown automatically at each end of the stroke, this movement being taken from either the main driving gear train to the table, or the slotter gearing, when slotting is being done. To throw out the feed, it is simply necessary to close a valve, cutting off the air supply.

The feed for the table, when slotting or transverse planing is being done, had not yet been placed in position when the photo, Fig. 3, was taken, but it is shown in Fig. 1, directly in front of and at the base of the upright. This feed operates practically the same as the feed for the cross head previously described, except that variation in stroke or amount of feed is obtained by an adjustable stop which regulates the amount of movement of the piston in the cylinder. This adjustment is made by the right-hand hand-wheel; the left-hand hand-wheel is for connecting and disconnecting the feed mechanism to the main driving works.

The slotter drive is shown in detail in Fig. 2. The description of the main drive on the opposite upright fits this one up to and including the pneumaite clutches. For the main drive, the power is then carried through the upright into the bed while for the slotter drive it is transmitted to the vertical square shaft and thence by bevels and spur gearing to the horizontal square shaft running along the top of the cross slide. The pinion of this shaft drives the large gear, of which only the cover can be seen. The rack pinion which gears into the back of the cutter bar is on the same shaft with this gear. The pinion on the square shaft slides and can be thrown in or out of gear as desired, so that either or both bars can be used. The disc shown just above the motor controls the length of stroke. This disc is driven from the main train of slotter gearing and the adjustable stops on its periphery can be set at any desired point and effect the reversal in the same way as do dogs on the side of a planer table. Near the bottom of the square vertical shaft may be seen the bevel gear on the end of a horizontal shaft, which goes across the bed and can be connected to the mechanism operating the valve of the feed cylinder on the opposite side, as mentioned in the description of the feed for the heads.

In Figs. 1 and 3 can be seen a vertical shaft where the reversing hand lever of a standard planer is usually found; it will be

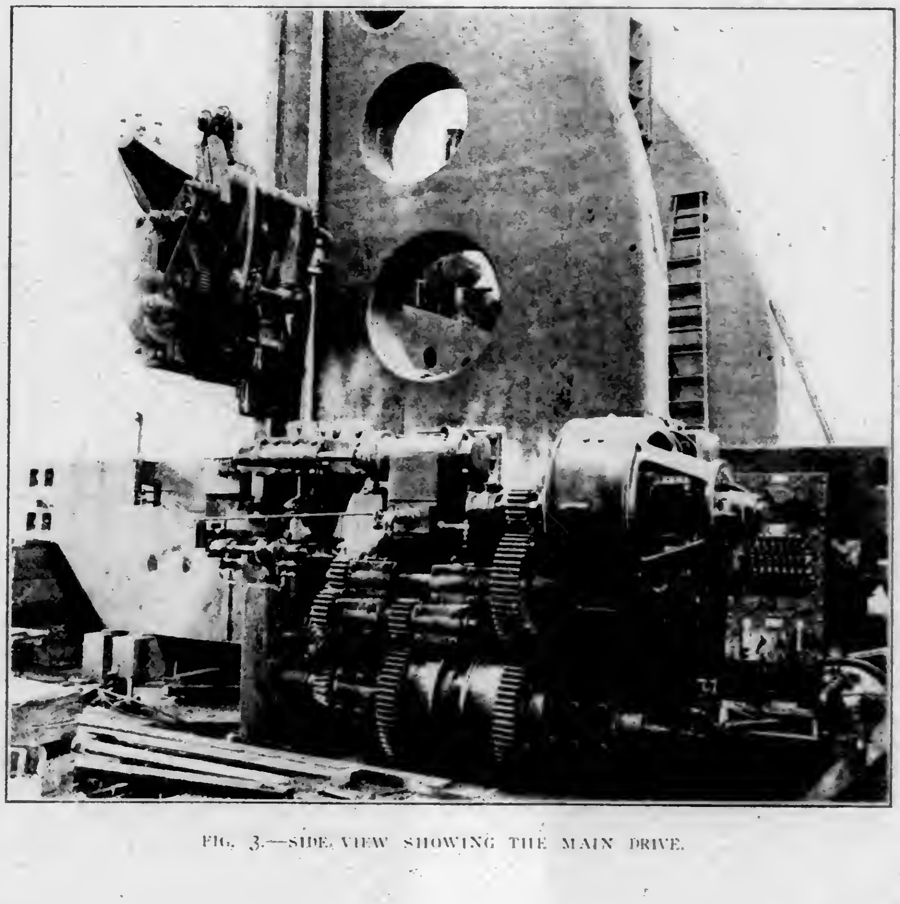


FIG. 3.—SIDE VIEW SHOWING THE MAIN DRIVE.

noticed that there are two sockets at the upper end, in one of which is a handle. The upper socket is connected to a shaft which runs down to the bottom lever or crank and forms the hand-control of the slotter. The lower socket is the one that controls the movement of the table when regular planing is being done and is connected by a lever and rods to the reversing dogs on the bed on both sides. Only one handle is furnished for each side and thus mistakes arising from throwing the wrong lever are avoided.

Owing to the great weight and large dimensions, it was impracticable, both from a manufacturing and a shipping standpoint, to make the bed or table in one piece. They were, therefore, divided to bring them within reasonable limits. The central section of the bed is divided longitudinally into three parts and the two end sections into two parts, or seven parts in all. The total weight of the bed is about 275,000 pounds. The table is made in two sections divided longitudinally in the center and weighs about 140,000 pounds.

The motor for fast traverse of heads is shown on the end of the cross slide in Fig. 3. The reversing is done through friction clutches and a safety is provided which prevents throwing in the fast traverse and the feed mechanism at the same time. The motor for operating the rail is situated at the top of the upright, as shown in Fig. 1. This motor is connected at all times to the elevating screws and is stopped, started and reversed electrically.

HENDERSHOT SHAFT COUPLING.

A new shaft coupling of great strength, and which may be quickly and conveniently applied, has just been placed on the market by Manning, Maxwell & Moore, Inc., of 85 Liberty street, New York. It is known as the Hendershot; the different parts, as well as an assembled view, are shown in the accompanying illustrations.

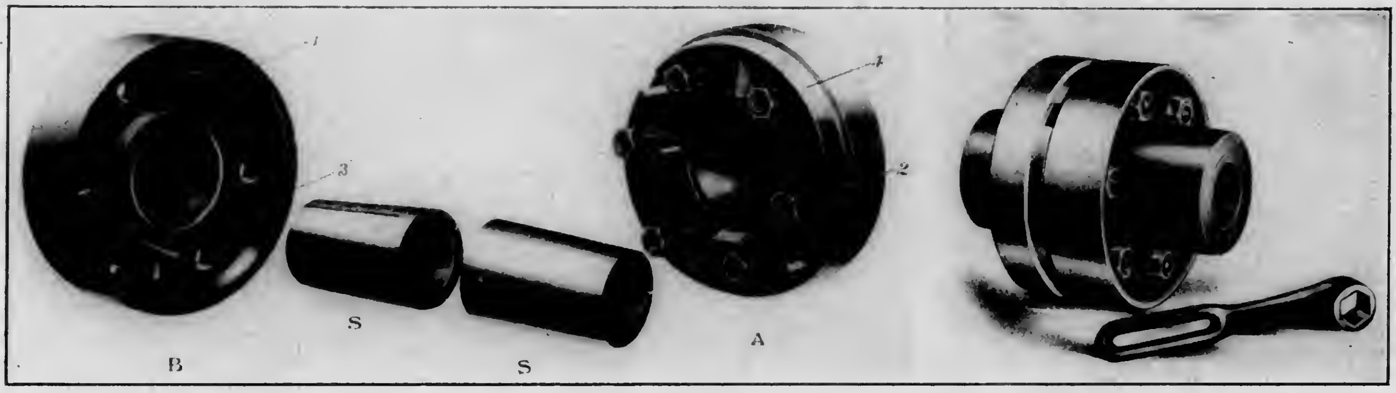
The two short taper compression sleeves, S-S, make it possible to slip the two halves of the coupling in place while the shafting is on the floor, hoist the pieces of shafting into position independently, and bolt them together as easily as the plain flanged coupling, but without the large amount of preliminary work which is necessary to put the flanged coupling on the shaft and true up the faces. Although it is not shown in the illustration, one of the four slots in each sleeve is cut through the entire length of the sleeve, thus allowing greater compression.

The shells A and B have lugs which interlock and relieve the bolts of shearing strains, thus making a rigid and durable construction. However, more bolts than usual are provided because of the large compression area of the coupling and to provide an unusually large factor of safety.

In applying the coupling the shells A and B are first slipped on the shafting. Sleeves S-S are then put in place and the shells are drawn over them, the lugs being brought into an interlocking position. The shells are then bolted together; the fits 3 and 4 practically true up the coupling, but perfect alignment is assured by keeping the faces 1 and 2 parallel. The coupling is easily taken apart by screwing two bolts in holes that are tapped in one of the shells, thus forcing them apart.

This coupling makes possible a considerable saving in time in putting up shafting and is specially advantageous where it is necessary to put up an additional piece of shafting and couple it to the end of a piece already erected and in use.

If the shafts to be coupled vary a little in size the Hendershot coupling will adjust itself. The coupling is made of the best gray iron and every coupling is put together on a test pin and inspected before it leaves the factory.

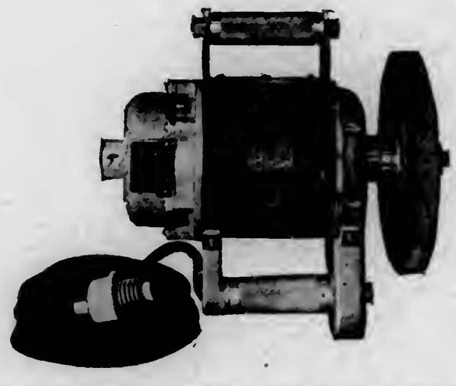


HENDERSHOT SHAFT COUPLING.

PORTABLE METAL GRINDING AND BUFFING MACHINE.

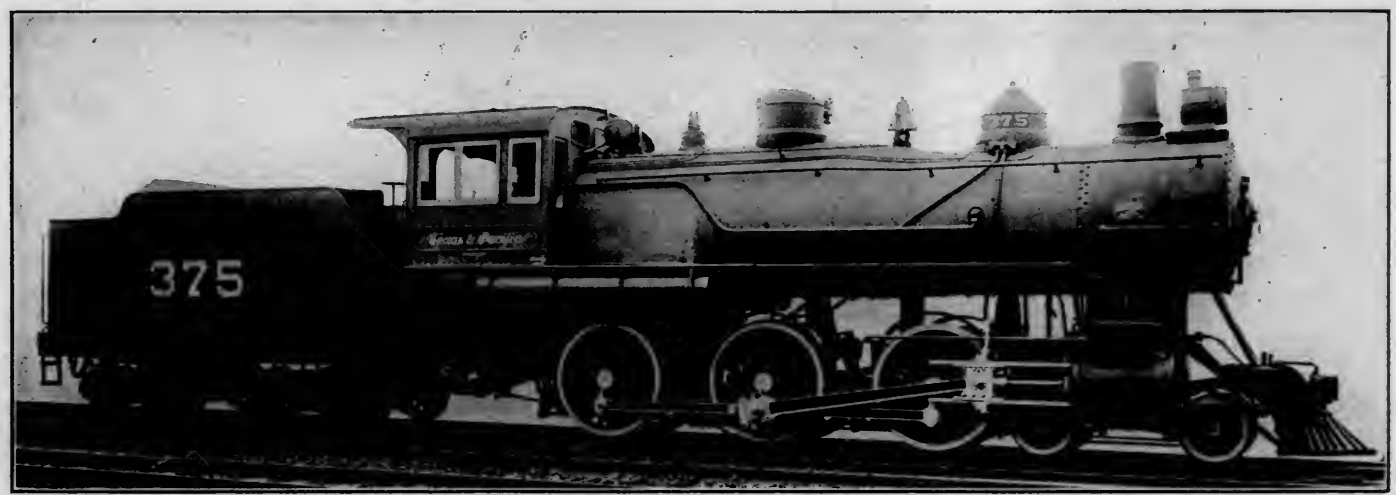
A portable, electrical grinding machine for use in grinding castings in machine shops and foundries, or for buffing, is illustrated herewith. The operating and controlling switch is located in the right hand handle and the operator does not, therefore, have to release his hold on the machine in order to start or stop it. The machine is air cooled by a rotary fan mounted on the armature shaft. The bearings are of phosphor bronze, are arranged for convenient lubrication and are provided with dust proof oilers.

It is designed so that a buffing wheel or a specially shaped emery wheel may be interchanged. The emery wheel is 8 in. in diameter and has a ¾-in. face. The machine has an eye-bolt fitted on the top so that it can be suspended from a spring, or be provided with a cord and counterbalance, relieving the operator of the weight. It weighs 25 lbs. complete and is furnished for 110, 220 or 550 volts direct current. It can also be wound for any special voltage from 75 to 650. As regularly furnished it is provided with 10 feet of attaching cord. Power may be taken from any ordinary lamp socket.



PORTABLE ELECTRICAL GRINDER AND BUFFING MACHINE.

These grinders are made by the Cincinnati Electrical Tool Company, Cincinnati, Ohio.



VERY HEAVY TEN-WHEEL FREIGHT LOCOMOTIVE—TEXAS & PACIFIC RAILWAY.

TEN-WHEEL FREIGHT LOCOMOTIVE.

TEXAS & PACIFIC RAILWAY.

The American Locomotive Company has recently delivered from its Rogers works to the Texas & Pacific Railway twenty locomotives of the ten-wheel type. These engines have been placed in freight service and are now successfully handling trains of 885 tons on maximum grades of 1⅓ per cent.

For locomotives of this type, intended for freight service, these engines exceed in total weight anything on our records. They also are designed to give a ratio of weight on drivers to total weight which approaches that usually found in consolidation locomotives. Of the total weight of 197,000 lbs., 165,000 or 84 per cent. is carried on the driving wheels. The average figure for this type of locomotive is from 75 to 76 per cent. To attain this, the front pair of driving wheels has been located but 90 in. back of the centre line of the cylinders and but 52 in. from the centre of the rear truck axle. This weight on drivers gives an average load per driving axle of 55,000 lbs., which approaches the maximum that has been attempted in this country.

The cylinders are 22 x 28 in.; the boiler pressure 210 lbs., and the driving wheels 63 in. in diameter. This gives a maximum tractive effort of 38,400 lbs., and a ratio of adhesion of 4.3. The cylinders are equipped with balance slide valves actuated by the Stephenson type of valve motion. The valves have a maximum travel of 6 in. and are set with a lead of 1-32 in. in full gear.

The boiler, as can be seen from an inspection of the ratios, is of the usual size and capacity for this weight of locomotive. The barrel is built up of three rings, of which the centre one is the slope sheet. The firebox, which has a vertical back head and throat, offers nothing novel in design. The crown sheet is supported by crown bars. The mud ring is 3½ in. wide at the back, which space increases to 5 in. at the crown, and is 5 in. wide at the sides and front.

A departure from the present ordinary practice is the use of under-hung springs on these locomotives. A semi-elliptic spring is carried under each journal box, the weight being transferred to it by wrought iron hangers hooking over the top of the box. The three pairs of driving wheels on either side are equalized together. The frames are 5 in. wide, of cast steel, with double front rails.

The general dimensions, weights and ratios are as follows:

GENERAL DATA.	
Gauge	4 ft. 8½ in.
Service	Freight
Fuel	Bit. coal
Tractive effort	38,400 lbs.
Weight in working order	197,000 lbs.
Weight on drivers	165,000 lbs.
Weight on leading truck	32,000 lbs.
Weight of engine and tender in working order	329,867 lbs.
Wheel base, driving	14 ft. 10 in.
Wheel base, total	26 ft. 4 in.
Wheel base, engine and tender	55 ft. 9¾ in.
RATIOS.	
Weight on drivers ÷ tractive effort	4.30
Total weight ÷ tractive effort	5.13
Tractive effort x diam. drivers ÷ heating surface	825.00
Total heating surface ÷ grate area	63.50
Firebox heating surface ÷ total heating surface, per cent.	6.80
Weight on drivers ÷ total heating surface	56.00
Total weight ÷ total heating surface	67.00
Volume both cylinders, cu. ft.	12.30
Total heating surface ÷ vol. cylinders	236.00
Grate area ÷ vol. cylinders	3.78
CYLINDERS.	
Kind	Simple
Diameter and stroke	22 x 28 in.
VALVES.	
Kind	Bal. slide
Greatest travel	6 in.
Outside lap	1 in.
Inside clearance	0 in.
Lead in full gear	1/32 in.
WHEELS.	
Driving, diameter over tires	63 in.
Driving, thickness of tires	3½ in.
Driving journals, diameter and length	10 x 13 in.
Engine truck wheels, diameter	30 in.
Engine truck, journals	6 x 10 in.
BOILER.	
Style	E. W. T.
Working pressure	210 lbs.
Outside diameter of first ring	70⅛ in.
Firebox, length and width	99 x 67¼ in.
Firebox plates, thickness	⅜ & ½ in.
Firebox, water space	F. & S.—5, B.—3½ in.
Tubes, number and outside diameter	326—2 in.
Tubes length	16 ft.
Heating surface, tubes	2,731 sq. ft.
Heating surface, firebox	200 sq. ft.
Heating surface, total	2,931 sq. ft.
Grate area	46.3 sq. ft.
Smokestack, diameter	18 in.
Smokestack, height above rail	189½ in.
TENDER.	
Frame	13 in. channels
Weight, empty	54,700 lbs.
Wheels, diameter	33 in.
Journals, diameter and length	5½ x 10 in.
Water capacity	6,500 gals.
Coal capacity	12 tons

THE STOREKEEPER.—If the general storekeeper is going to keep intelligently in touch with the work of the road for which he is obliged to supply the materials, if he is intelligently to know that the amount of material which he has on hand is adequate and not too great, he must be in constant touch with the work that is going on in the field. He must know of his own knowledge all the operations of the road involving the use of material and how the material is issued and why it is used and how much of it is necessary or likely to be necessary for any given purpose, and above all things he must know personally what his subordinates are doing.—*Mr. G. G. Yeomans at the meeting of the Railway Storekeepers' Association.*

TRAVELING ENGINEERS SHOULD BE INSTRUCTORS, NOT INSPECTORS.—Road foremen of engines and traveling engineers ought not forget that they are instructors, not mere inspectors, and as good instructors they need never be without a good subject to discuss as the men will furnish the questions in abundant volume just as soon as they realize that the instructor is also an ordinary man who does not pretend to be beyond "showing."—*Mr. D. R. MacBain before the Traveling Engineers' Association.*

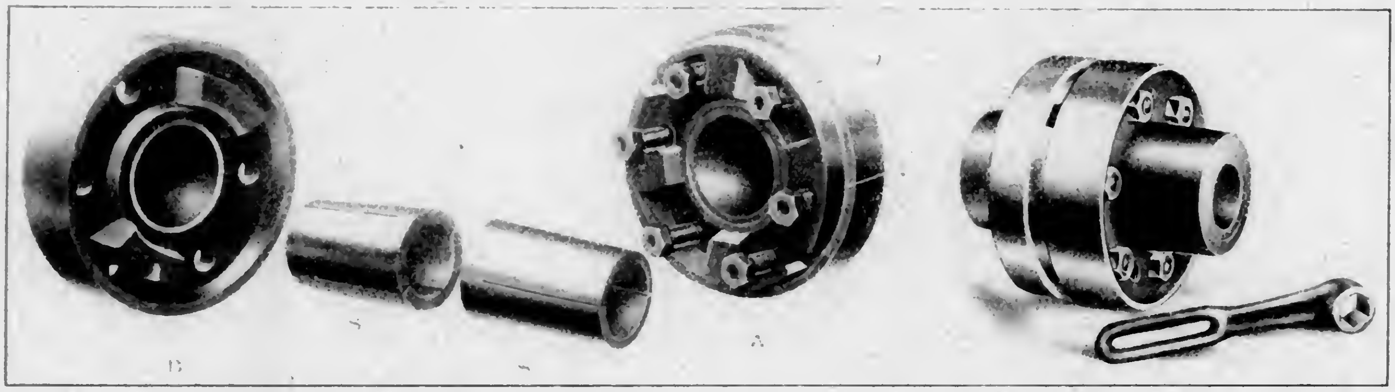
noticed that there are two sockets at the upper end, in one of which is a handle. The upper socket is connected to a shaft which runs down to the bottom lever or crank and forms the hand-control of the slotter. The lower socket is the one that controls the movement of the table when regular planing is being done and is connected by a lever and rods to the reversing dogs on the bed on both sides. Only one handle is furnished for each side and thus mistakes arising from throwing the wrong lever are avoided.

Owing to the great weight and large dimensions, it was impracticable, both from a manufacturing and a shipping standpoint, to make the bed or table in one piece. They were, therefore, divided to bring them within reasonable limits. The central section of the bed is divided longitudinally into three parts and the two end sections into two parts, or seven parts in all. The total weight of the bed is about 275,000 pounds. The table is made in two sections divided longitudinally in the center and weighs about 140,000 pounds.

The motor for fast traverse of heads is shown on the end of the cross slide in Fig. 3. The reversing is done through friction clutches and a safety is provided which prevents throwing in the fast traverse and the feed mechanism at the same time. The motor for operating the rail is situated at the top of the upright, as shown in Fig. 1. This motor is connected at all times to the elevating screws and is stopped, started and reversed electrically.

HENDERSHOT SHAFT COUPLING.

A new shaft coupling of great strength, and which may be quickly and conveniently applied, has just been placed on the market by Manning, Maxwell & Moore, Inc., of 85 Liberty street, New York. It is known as the Hendershot; the different parts, as well as an assembled view, are shown in the accompanying illustrations.



HENDERSHOT SHAFT COUPLING.

The two short taper compression sleeves, S-S, make it possible to slip the two halves of the coupling in place while the shafting is on the floor, hoist the pieces of shafting into position independently, and bolt them together as easily as the plain flanged coupling, but without the large amount of preliminary work which is necessary to put the flanged coupling on the shaft and true up the faces. Although it is not shown in the illustration, one of the four slots in each sleeve is cut through the entire length of the sleeve, thus allowing greater compression.

The shells A and B have lugs which interlock and relieve the bolts of shearing strains, thus making a rigid and durable construction. However, more bolts than usual are provided because of the large compression area of the coupling and to provide an unusually large factor of safety.

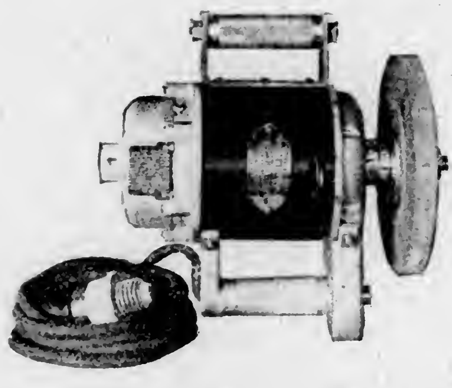
In applying the coupling the shells A and B are first slipped on the shafting. Sleeves S-S are then put in place and the shells are drawn over them, the lugs being brought into an interlocking position. The shells are then bolted together; the fits 3 and 4 practically true up the coupling, but perfect alignment is assured by keeping the faces 1 and 2 parallel. The coupling is easily taken apart by screwing two bolts in holes that are tapped in one of the shells, thus forcing them apart.

This coupling makes possible a considerable saving in time in putting up shafting and is specially advantageous where it is necessary to put up an additional piece of shafting and couple it to the end of a piece already erected and in use.

If the shafts to be coupled vary a little in size the Hendershot coupling will adjust itself. The coupling is made of the best gray iron and every coupling is put together on a test pin and inspected before it leaves the factory.

PORTABLE METAL GRINDING AND BUFFING MACHINE.

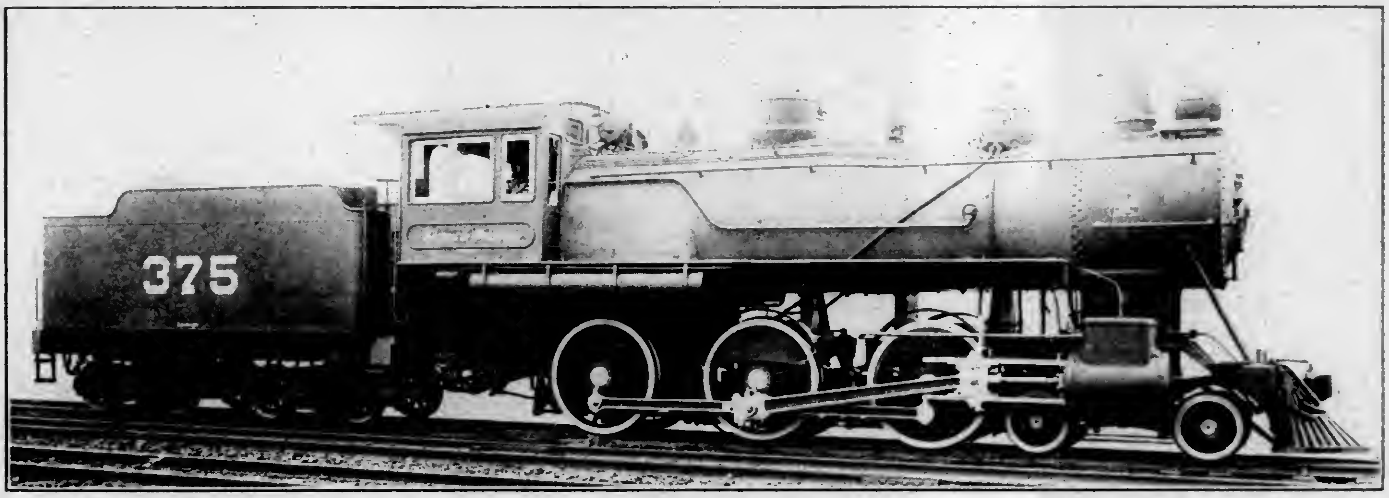
A portable, electrical grinding machine for use in grinding castings in machine shops and foundries, or for buffing, is illustrated herewith. The operating and controlling switch is located in the right hand handle and the operator does not, therefore, have to release his hold on the machine in order to start or stop it. The machine is air cooled by a rotary fan mounted on the armature shaft. The bearings are of phosphor bronze, are arranged for convenient lubrication and are provided with dust proof oilers.



PORTABLE ELECTRICAL GRINDER AND BUFFING MACHINE.

It is designed so that a buffing wheel or a specially shaped emery wheel may be interchanged. The emery wheel is 8 in. in diameter and has a 3/4 in. face. The machine has an eye-bolt fitted on the top so that it can be suspended from a spring, or be provided with a cord and counterbalance, relieving the operator of the weight. It weighs 25 lbs. complete and is furnished for 110, 220 or 550 volts direct current. It can also be wound for any special voltage from 75 to 650. As regularly furnished it is provided with 10 feet of attaching cord. Power may be taken from any ordinary lamp socket.

These grinders are made by the Cincinnati Electrical Tool Company, Cincinnati, Ohio.



VERY HEAVY TEN-WHEEL FREIGHT LOCOMOTIVE—TEXAS & PACIFIC RAILWAY.

TEN-WHEEL FREIGHT LOCOMOTIVE.

TEXAS & PACIFIC RAILWAY.

The American Locomotive Company has recently delivered from its Rogers works to the Texas & Pacific Railway twenty locomotives of the ten-wheel type. These engines have been placed in freight service and are now successfully handling trains of 885 tons on maximum grades of 1⅓ per cent.

For locomotives of this type, intended for freight service, these engines exceed in total weight anything on our records. They also are designed to give a ratio of weight on drivers to total weight which approaches that usually found in consolidation locomotives. Of the total weight of 197,000 lbs., 165,000 or 84 per cent. is carried on the driving wheels. The average figure for this type of locomotive is from 75 to 76 per cent. To attain this, the front pair of driving wheels has been located but 90 in. back of the centre line of the cylinders and but 52 in. from the centre of the rear truck axle. This weight on drivers gives an average load per driving axle of 55,000 lbs., which approaches the maximum that has been attempted in this country.

The cylinders are 22 x 28 in.; the boiler pressure 210 lbs., and the driving wheels 63 in. in diameter. This gives a maximum tractive effort of 38,400 lbs., and a ratio of adhesion of 4.3. The cylinders are equipped with balance slide valves actuated by the Stephenson type of valve motion. The valves have a maximum travel of 6 in. and are set with a lead of 1-32 in. in full gear.

The boiler, as can be seen from an inspection of the ratios, is of the usual size and capacity for this weight of locomotive. The barrel is built up of three rings, of which the centre one is the slope sheet. The firebox, which has a vertical back head and throat, offers nothing novel in design. The crown sheet is supported by crown bars. The mud ring is 3½ in. wide at the back, which space increases to 5 in. at the crown and is 5 in. wide at the sides and front.

A departure from the present ordinary practice is the use of under-hung springs on these locomotives. A semi-elliptic spring is carried under each journal box, the weight being transferred to it by wrought iron hangers hooking over the top of the box. The three pairs of driving wheels on either side are equalized together. The frames are 5 in. wide, of cast steel, with double front rails.

The general dimensions, weights and ratios are as follows:

GENERAL DATA.	
Gauge	4 ft. 8½ in.
Service	Freight
Fuel	Bit. coal
Tractive effort	38,400 lbs.
Weight in working order	197,000 lbs.
Weight on drivers	165,000 lbs.
Weight on leading truck	32,000 lbs.
Weight of engine and tender in working order	329,867 lbs.
Wheel base, driving	14 ft. 10 in.
Wheel base, total	26 ft. 4 in.
Wheel base, engine and tender	55 ft. 9¾ in.
RATIOS.	
Weight on drivers ÷ tractive effort	4.30
Total weight ÷ tractive effort	5.13
Tractive effort x diam. drivers ÷ heating surface	825.00
Total heating surface ÷ grate area	63.50
Firebox heating surface ÷ total heating surface, per cent.	6.80
Weight on drivers ÷ total heating surface	56.00
Total weight ÷ total heating surface	67.00
Volume both cylinders, cu. ft.	12.30
Total heating surface ÷ vol. cylinders	236.00
Grate area ÷ vol. cylinders	3.78
CYLINDERS.	
Kind	Simple
Diameter and stroke	22 x 28 in.
VALVES.	
Kind	Bal. slide
Greatest travel	6 in.
Outside lap	1 in.
Inside clearance	0 in.
Lead in full gear	1/32 in.
WHEELS.	
Driving, diameter over tires	63 in.
Driving, thickness of tires	3½ in.
Driving journals, diameter and length	10 x 13 in.
Engine truck wheels, diameter	30 in.
Engine truck, journals	6 x 10 in.
BOILER.	
Style	E. W. T.
Working pressure	210 lbs.
Outside diameter of first ring	70⅛ in.
Firebox, length and width	99 x 67¼ in.
Firebox plates, thickness	⅜ & ½ in.
Firebox, water space	F. & S.—5, B.—3½ in.
Tubes, number and outside diameter	326—2 in.
Tubes, length	16 ft.
Heating surface, tubes	2,731 sq. ft.
Heating surface, firebox	200 sq. ft.
Heating surface, total	2,931 sq. ft.
Grate area	46.3 sq. ft.
Smokestack, diameter	18 in.
Smokestack, height above rail	189½ in.
TENDER.	
Frame	13 in. channels
Weight, empty	54,700 lbs.
Wheels, diameter	33 in.
Journals, diameter and length	5½ x 10 in.
Water capacity	6,500 gals.
Coal capacity	12 tons

THE STOREKEEPER.—If the general storekeeper is going to keep intelligently in touch with the work of the road for which he is obliged to supply the materials, if he is intelligently to know that the amount of material which he has on hand is adequate and not too great, he must be in constant touch with the work that is going on in the field. He must know of his own knowledge all the operations of the road involving the use of material and how the material is issued and why it is used and how much of it is necessary or likely to be necessary for any given purpose, and above all things he must know personally what his subordinates are doing.—*Mr. G. G. Yeomans at the meeting of the Railway Storekeepers' Association.*

TRAVELING ENGINEERS SHOULD BE INSTRUCTORS, NOT INSPECTORS.—Road foremen of engines and traveling engineers ought not forget that they are instructors, not mere inspectors, and as good instructors they need never be without a good subject to discuss as the men will furnish the questions in abundant volume just as soon as they realize that the instructor is also an ordinary man who does not pretend to be beyond "showing."—*Mr. D. R. MacBain before the Traveling Engineers' Association.*

PERSONALS.

Mr. Harvey Halverson has been appointed master car builder of the Wisconsin Central Ry. at Fond du Lac, Wis.

Mr. Elliott Brooks has been appointed master mechanic of the Mobile and Ohio R. R. at Whistler, Ala., succeeding Mr. Enright.

Mr. L. G. Wallace has been appointed acting master mechanic at Guadalajara, Mexican Central Railway.

Mr. Willard Lincoln, master mechanic of the St. Paul and Minnesota divisions of the Northern Pacific Railway, has resigned.

Mr. Carl J. Mellin, formerly designing engineer of the American Locomotive Company at Schenectady, has been appointed consulting engineer.

Mr. R. D. Gibbons has been appointed general foreman of the Saltillo shops of the Mexican Central Railway, vice Mr. J. G. Smith, transferred.

Mr. R. N. Millice has been appointed master mechanic of the Aguascalientes Division of the Mexican Central Railway, vice Mr. R. D. Gibbons, transferred.

Mr. J. W. Cyr, assistant master mechanic of the Chicago, Burlington and Quincy Railway at Hannibal, Mo., has been promoted to master mechanic.

Mr. M. Marea, road foreman of engines, has been appointed master mechanic of the Toledo, St. Louis & Western Ry. at Frankfort, Ind.

Mr. J. M. Barnes has been appointed master mechanic of the Rio Grande, Sierra Madre & Pacific Ry., with office at Ciudad Juarez, Mexico.

Mr. C. J. Morrison has been appointed standardizing engineer of the Atchison, Topeka & Santa Fe Railway, with headquarters at Topeka, Kans.

Mr. W. J. Dempster has been appointed master mechanic of the Monterey Division of the Mexican Central Ry., vice Mr. J. A. Lewis, transferred.

Mr. Grant Hall has been appointed superintendent of motive power of the western lines of the Canadian Pacific Ry., with office at Winnipeg, Man.

Mr. C. T. Hessmer has been appointed master mechanic of the Minnesota division of the Northern Pacific Railway, with headquarters at Staples, Minn.

Mr. Silas Zwight has been appointed master mechanic of the St. Paul division of the Northern Pacific Railway, with headquarters at Minneapolis, Minn.

Mr. George W. Dickson, master mechanic of the Chicago, Indianapolis & Louisville R. R. at Peru, Ind., has resigned to take a similar position with the Grand Trunk Ry.

Mr. E. A. Walton, division superintendent of motive power of the New York Central R. R. at Oswego, has been transferred to West Albany in the same capacity.

Mr. S. W. Mullinix, superintendent of motive power of the southwestern district of the Chicago, Rock Island & Pacific Ry., has transferred his office from Topeka to Horton, Kan.

Mr. J. C. Crawford, fuel engineer of the Chicago, Burlington & Quincy Railway, has had his jurisdiction extended to include the inspection of all coal used by the system.

Mr. K. L. Dusser has been appointed master mechanic of the Chicago, Indianapolis & Louisville R. R. at Peru, Ind.

Mr. J. L. Butler has been appointed master mechanic of the Missouri Pacific Ry. at Atchison, Kan., to succeed Mr. L. J. Mills.

Mr. W. P. Chrysler has been appointed superintendent of motive power of the Chicago Great Western Ry., with headquarters at Oelwein, Iowa, vice Mr. J. E. Chisholm, resigned.

Mr. Charles E. Fuller, formerly superintendent of motive power of the Chicago & Alton R. R., will undertake some special work for the mechanical department of the Erie R. R.

Mr. F. H. Reagan has been appointed general foreman of the locomotive department of the Collinwood Shops of the Lake Shore & Michigan Southern Railway, vice Mr. A. O. Berry, promoted.

Mr. J. S. Enright, master mechanic of the Mobile & Ohio Ry. at Whistler, Ala., has resigned to become superintendent of motive power of the International & Great Northern Ry. at Palestine, Texas.

Mr. John Kelker, for 27 years and until his retirement three years ago, master mechanic of the Denver & Rio Grande Ry. at Denver, Colo., died at his home in Los Angeles, Cal., Dec. 18, aged 81 years.

Mr. W. F. Buck, mechanical superintendent of the eastern grand division of the Atchison, Topeka & Santa Fe Ry., has been appointed general superintendent of motive power, with headquarters in Chicago.

Mr. Lyman W. Barber, secretary of the Standard Car Truck Company, was accidentally killed on the tracks of the South Side Elevated Railway, Chicago, on the night of January 5. Mr. Barber was 60 years of age and a widower.

Mr. C. H. Osborn, division foreman of the Chicago & Northwestern R. R. at Fond du Lac, Wis., has been appointed master mechanic of the Madison division, with office at Baraboo, Wis., vice Mr. W. H. Huffman, retired under the pension rules.

Mr. J. H. McGoff, master mechanic of the Missouri division of the Atchison, Topeka & Santa Fe Ry. at Fort Madison, Iowa, has been appointed to succeed Mr. W. F. Buck as mechanical superintendent of the Eastern grand division, with headquarters at Topeka, Kan.

Mr. W. Kennedy, heretofore master mechanic of the Grand Trunk Ry. at Toronto, Ont., has been appointed superintendent of the motive power and car department of the Central Vermont R. R., with headquarters at St. Albans, Vt., succeeding Mr. James Coleman, resigned.

Mr. George H. Haselton, division superintendent of motive power of the New York Central, in charge of shops at West Albany, N. Y., has been appointed assistant to Mr. John Howard, superintendent of motive power, with headquarters at New York City.

Mr. William McWood, superintendent of car department of the Grand Trunk Ry., after fifty-two years' service, retired Jan. 1, under the provisions of the pension rules recently adopted by the company, and is succeeded by Mr. James Coleman, superintendent of the motive power and car department of the Central Vermont Ry., with office at Montreal, Que.

Mr. F. J. Cole, mechanical engineer of the American Locomotive Company, has been appointed consulting engineer of the same company, with headquarters at Schenectady, N. Y. The office of mechanical engineer has been abolished and the duties heretofore performed by that officer are now included in the jurisdiction of Mr. Dalton, chief engineer.

Mr. C. L. Bundy, general superintendent of the car department of the Hicks Locomotive & Car Works, Chicago Heights, Ill., has been appointed general foreman of the Delaware, Lackawanna & Western Ry. shops at Scranton, Pa.

Mr. Charles E. Fuller, superintendent of motive power of the Chicago & Alton Ry., has resigned and the jurisdiction of Mr. Peter Maher, superintendent of motive power for the Toledo, St. Louis & Western Ry. will be extended to cover the Alton.

Dr. Coleman Sellers, one of the most distinguished mechanical engineers of the 19th century, died at his home in Philadelphia, December 28, 1907, at the age of 81 years. Dr. Sellers' reputation as a scientist and inventor was world-wide. Possibly the best known of his many large undertakings was that of the development and utilization of the hydraulic power at Niagara Falls, the success of which was principally due to his advice and direction. Dr. Sellers was a member and past president of the American Society of Mechanical Engineers and a member of the American Society of Naval Architects and Marine Engineers; the American Society of Civil Engineers; the American Philosophical Society; the Institute of Civil Engineers and the Institute of Mechanical Engineers of Great Britain and of the Society of Arts of Geneva, Switzerland. In 1887 he received the Royal Norwegian order of St. Olaf, conferred upon him by the King of Sweden in recognition of his valued services in his profession.

BOOKS.

Proceedings of the American Railway Master Mechanics' Association. Forty-first Annual Convention, Atlantic City, June, 1907. Published by the Association. J. W. Taylor, Secretary, 390 Old Colony Building, Chicago, Ill.

In additon to the complete commttee reports and the discussion of the reports and topical discussions this volume contains the revised rules and corrected standards and recommended practice of the Association.

How to Burn Illinois Coal Without Smoke. Bulletin No. 15 of the Engineering Experiment Station, University of Illinois. L. P. Breckenridge, Director, Urbana, Ill. Free on request.

This pamphlet gives the results of some very valuable and interesting investigations in the matter of smokeless combustion with Illinois coal. A few pages are devoted to the principles of combustion and the losses due to smoking chimneys, but the larger part of the bulletin relates to the constructive features of boiler settings and furnaces for smokeless firing.

Traveling Engineers' Association. Proceedings of the Fifteenth Annual Convention, September, 1907. Edited by Mr. W. O. Thompson, Secretary, East Buffalo, N. Y.

This volume contains the complete papers, together with the discussion thereon, presented at the last annual convention of the Association held in the Auditorium Hotel, Chicago, September 3 to 6, 1907. Among others, were important papers and reports on the subject of lubrication; coal economy; automatic stokers; hot water for washing out; the smoke nuisance; air brake requirements and superheated steam. A complete list of the membership of the Association, which now numbers 632, is included.

Proceedings of the Master Car and Locomotive Painters' Association. Thirty-eighth Annual Convention. Published by the Association. A. P. Dane, B. & M. R. R., Boston, Mass., Secretary.

The thirty-eighth annual convention of this association was held at St. Paul, Minn., September 10 to 13, 1907. A number of very interesting and valuable reports were submitted by the committees which, taken in connection with the discussion thereon and the individual papers by members, makes these proceedings of special value to those interested in car and locomotive painting. The subject of painting steel equipment, both passenger and freight, was thoroughly considered. The proceedings require a book of 124 pages.

The Science Year Book. Edited by Major B. F. S. Baden-Powell. Published by King, Sell & Olding, Ltd., 27 Chancery Lane, W. C., London, England. 6 x 9 in., cloth. Price, $1.25.

The first part of this book, about 150 pages, is devoted to astronomical data; general information concerning the earth and climatic conditions; physical and chemical notes; metrology; a summary of the progress of science during the past year; a glossary of recently introduced scientific terms and names; directories of scientific and technical periodicals, British public institutions, offices and universities, British, American and Canadian scientific societies; and a biographical directory of scientists. The remainder, about 400 pages, is a diary for 1908, although copies may be obtained without the diary, if desired.

Proceedings of the American Railway Master Mechanics' Association. Fortieth Annual Convention, Atlantic City, June, 1907. Published by the Association. J. W. Taylor, Secretary, 390 Old Colony Building, Chicago, Ill.

This volume contains complete reports, and discussions thereon, of all the committees reporting at the last convention, which included those on auditing; blanks forms for history of locomotive movements at terminals; blanks for reporting work on engines undergoing repairs; development of motor cars; mechanical stokers; lubrication; spacing of flues; superheating; valve gears; width of track on curves and design of wheel centres. The volume also contains the standards and specifications of the Association as well as a complete list of the members.

Electrocraft. An illustrated list of approved electrical fittings and revised national electrical code. 5¼ x 7½. 389 pages. Bound in paper. Published by the Electrocraft Publishing Company, Detroit, Mich. Price, 50c.

This book includes a list of fittings that have been examined and approved by the Underwriters' National Electrical Assoc. for use under the rules and regulations of the National Board of Fire Underwriters. These fittings are, in general, illustrated and the name of the manufacturer is given. The national electric code contained in the book gives the rules and requirements of the National Board of Fire Underwriters for the installation of electric wiring and apparatus. This is also very completely illustrated. A complete and comprehensive index of both sections is included.

CATALOGS.

METAL SAWING MACHINES.—A series of leaflets have been received from Nutter, Barnes & Co., Boston, Mass., presenting data as to their metal saw cutting off machines; also a description of a 20 in. automatic saw sharpener.

LIFTING MAGNETS.—A handsomely illustrated catalog has been received from The Electric Controller and Supply Company, Cleveland, Ohio, describing the various types of lifting magnets made by it, and their uses.

CENTRIFUGAL FANS.—The Jeffrey Mfg. Co., Columbus, O., is issuing a catalog which illustrates the construction and gives a table of capacities of the Jeffrey centrifugal fans, especially as adapted for mine ventilation, but also suitable for ventilation of other kinds.

LOCOMOTIVE REDUCING VALVES AND AIR PUMP GOVERNORS.—A catalog from the Mason Regulator Company, Boston, Mass., describes in detail The Mason locomotive reducing valves and air pump governors, and gives directions for applying and cleaning them.

METAL PLANING MACHINES.—The line of planers manufactured by the Woodward & Powell Planer Company, Worcester, Mass., is attractively illustrated and described in a 93-page catalog, which is prefaced by a number of views of different parts of the works.

PIPE COUPLINGS.—The Fairbanks Company, 316 Second avenue, Pittsburg, Pa., is issuing a card giving an illustration of the Dart patent union couplings manufactured in both plain and galvanized iron, having bronze seats, ball bearings and ground joints. A table of prices and sizes varying from ⅛ to 3½ in. is given.

THERMIT WELDING.—The Goldschmidt Thermit Company, 90 West street, New York City, is issuing a leaflet which illustrates and describes the proper procedure for welding broken electric motor cases and clearly shows the great advantage of this method of repair, both as to cost of welding and the saving of time.

Turret Drills.—A catalog from A. D. Quint, Hartford, Conn., describes various types of vertical turret drills. These are made in four sizes and with from four to twelve spindles.

Drop Forgings.—The drop forgings, including a large variety of wrenches, made by the Page-Storms Drop Forge Company, Springfield, Mass., are described in a very complete catalog received from them.

Corliss Engines.—"Nomenclature of Murray Corliss Engines" is the title of a unique publication issued by The Murray Iron Works Company, Burlington, Iowa. It is known as Series D, No. 7. The names of the various parts are shown on assembled drawings of different types of these engines; also on perspective and sectional views of different portions of the engine. There are also a number of halftone illustrations.

A Gigantic Planer.—The January number of the *Progress Reporter*, issued by the Niles-Bement-Pond Company, 111 Broadway, New York, is devoted entirely to the 422½ ton planer, recently furnished to the Mackintosh-Hemphill Company of Pittsburgh, and described in another page of this issue. A large double page, and fourteen full page illustrations, are presented in connection with a very complete description of the machine.

Ball Bearing Drill Presses.—This is the title of an attractive catalog from The Henry & Wright Manufacturing Company, Hartford, Conn. The sensitive drills made by this company are of both the vertical type, with one or more spindles, and of the radial type. The use of ball bearings greatly reduces the friction, making the drills more efficient and economical. The Rice idler system of belting, which is used, furnishes four spindle speeds with two-step pulleys and one belt.

High Pressure Jacks.—A small pamphlet from the Security Register & Manufacturing Company, St. Louis and New York, in which the Roth universal high pressure jacks are described. These jacks are fitted with ball bearings. Details are given of a test of a 20 ton jack made at the United States Navy Yard, New York. One man lifted 27.34 tons with an 8 in. lever and 41.73 tons with an 18 in. lever; also lifted 62.5 tons without injuring the jack.

New Type of Storage Battery.—The Standard Electric Accumulator Co., 141 Broadway, New York, is issuing a very attractive catalog illustrating and describing its type of accumulator, which is distinguished by the fact that the plates cannot buckle or disintegrate, since each is inclosed in a very thin, strong and porous box of unglazed pottery. This accumulator is remarkably light for its capacity and is practically indestructible when given proper usage.

Drilling Machines and Engine Lathes.—A loose-leaf catalog from the Prentice Bros. Company, Worcester, Mass., illustrates and describes the various lines of drilling machines and engine lathes manufactured by them. These include sensitive drills; vertical drills arranged for belt or motor drive, also equipped with mechanical speed changing device and tapping attachments; radial drills and universal tables for use in connection with them; lathes of the ordinary, high speed and turret types.

German Locomotives for Export.—A. Borsig, locomotive builder, of Tegel, Germany, is issuing a pamphlet illustrating and describing many different designs of locomotives built by his works for export during the past two years. This pamphlet is printed in four languages, including English, and portrays some very interesting designs of locomotives. A table is included showing that the total output of these works to May, 1907, was 6,783 locomotives for service in 33 different countries. The more important dimensions of each design are included.

Electric Generators and Switchboard Panels.—The Crocker-Wheeler Company, Ampere, N. J., are issuing a number of new bulletins, each of which confines itself to a description of certain separate machines or pieces of apparatus. One of these is devoted to small type direct current generators, showing these machines in several forms and including tables of capacities, sizes and speeds. Other bulletins are being sent out on the subject of switchboard panels, one being for three phase alternating current, another for induction motor panels, and the third for direct current combined generator and feeder panels.

Shop and Factory Specialties.—The Manufacturing Equipment and Engineering Company. 209 Washington street, Boston, Mass., has prepared a small catalog describing the specialties made by it. These include individual wash bowls arranged in batteries for shop and factory use; cylindrical metal lockers, known as the Cly-Mee-Co.; improved soda and potash kettles with thermostat; thermostatic controlling apparatus; shop stools, work benches and drawers; storage racks, standard bench legs and steel boxes and trays. The above equipment is made fireproof, as far as possible, and is designed to be thoroughly sanitary.

Karbolith Flooring.—The American Mason Safety Tread Company, 702 Old South Building, Boston, Mass., is sending out a neat, concisely worded pamphlet describing Karbolith flooring, which is said to be fireproof, sanitary, noiseless, elastic, and durable. It is composed of different materials, some of which are of a fibrous and cellular nature and these produce a slightly elastic but hard and tough body. It is laid in a plastic state, similar to cement or plaster and hardens quickly. It weighs about 3 pounds to a foot when laid about ½ in. thick. Plates are presented showing the different colors and shades in which this material may be furnished.

Engines for Driving Fans.—The Massachusetts Fan Company, Watertown, Mass., has just issued an additional section to its perpetual catalog, which comprises 16 pages and is entitled "Vertical and Horizontal Engines for Fan Driving." This includes illustrations, descriptions and horse power tables. The entire catalog is now brought up to a total of 116 pages of exceptionally valuable matter relating to mechanical draft apparatus.

Short Jacks.—A folder from A. O. Norton, Inc., 286 Congress street, Boston, Mass., illustrates three new patterns of jacks which have been especially designed for heavy, low-set loads in roundhouses and car repair yards. The smaller one has a capacity of 25 tons, height of 9 in., rise of 3 in., and weighs 50 lbs. The second has a capacity of 35 tons, height of 20 in., rise of 8 in., and weighs 175 lbs. The most powerful one has a capacity of 50 tons, height of 20 in., rise of 5 in., and weighs 250 lbs.

Rolling Doors and Shutters.—Catalog No. 34 from the James G. Wilson Manufacturing Company, 3 West 29th street, New York, fully describes and illustrates the various types of rolling doors, rolling shutters, and partitions which are made by that company in bronze, steel and wood. Illustrations are given of corrugated rolling steel doors and shutters which have been in service for as long as thirty years or more. A test of a corrugated shutter made in the Underwriters' Laboratory, under instructions from the National Board of Fire Underwriters, is also described. Several illustrations shows applications of the different types of doors to railroad shops, roundhouses and freight houses.

Cork Inserts for Clutches and Pulleys.—Several pamphlets have been received from the National Brake & Clutch Company, 16 State street, Boston, concerning the use of cork inserts in clutches, pulleys and brakes. Reports of camparative tests of pulleys, made at the Worcester Polytechnic Institute, are given. These tests included the following types of pulleys: cast iron, cast iron with cork inserts and fiber with cork inserts. The use of cork inserts increases the coefficient of friction greatly.

Another of the pamphlets deals with the use of these inserts in connection with automobile clutches and brakes. A report of a test made by Prof. Hollis of Harvard University is reproduced showing the increase of the coefficient of friction due to the use of cork inserts in cast iron plates.

Electrical Apparatus.—The General Electric Company is issuing a number of new bulletins, each being a complete and interesting description of some particular instrument or machine manufactured by it. These include bulletin No. 4,550 on carbon break circuit breakers, which are designed for small reliable automatic protective devices for both direct and alternating current. Bulletin No. 4,551 shows the Thompson horizontal edge-wise measuring instruments for switchboard service of all kinds. Bulletin No. 4,556 is on the subject of the series luminous arc rectifier system, which permits the operation of direct current luminous arc lamps from alternating current central stations. Bulletin No. 4,557 is on the subject of controllers for electric cars, particularly as adapted for high voltages.

Ball Bearings.—An attractive catalog has been received from the Chapman Double Ball Bearing Company of America, 40 Bristol street, Boston, Mass. The advantages of the Chapman double ball bearing are clearly presented in contrast to the ordinary ball bearing. A report of tests made by Mr. Henry Souther is given and different applications of the bearings are described and illustrated. These include shafting bearings, street car journal bearings, automobile wheel bearings and thrust and step bearings. Several letters of testimonial are given including one from the superintendent's office of the Gardner, Westminster & Fitchburg Street Railway Company, Gardner, Mass., in which the service given by a car equipped with ball bearing journal bearings that has been in service five years is described.

Locks.—Two interesting pamphlets, well printed, attractively illustrated, and forcibly bringing out the advantages of the Yale night latch, have been prepared for distribution by the Yale & Towne Mfg. Company, 9 Murray street, New York City. The first is entitled "The Night Latch, What It Is." The prominent features of the Yale lock are clearly presented by tracing its development and by means of a number of simple illustrations.

The second is entitled "His First Latch Key"; some of the advantages of the Yale night latch are incidentally brought out in connection with quite a readable storiette.

In addition to the above there are twelve slips or leaflets, each containing on one side a bit of "Yale lock philosophy" and on the other side an illustrated description of one of twelve types of night latches in general use.

NOTES.

Ward Equipment Company.—Mr. A. E. Robbins has resigned his post with the Gold Car Heating and Lighting Company to take a prominent position with the Ward Equipment Company.

Riehle Bros. Testing Machine Company.—The Board of Directors of the above company, at a meeting held on December 30, declared an annual dividend of 6 per cent. on the capital stock of the company for the year 1907.

New England Foundrymen's Association.—Mr. Walter B. Snow, of Boston, a former president of this association, and now engaged in independent practice as a publicity engineer, was recently elected an honorable president.

(Established 1832).

AMERICAN ENGINEER AND RAILROAD JOURNAL.

MARCH, 1908.

STEEL PASSENGER EQUIPMENT.*

BY CHARLES E. BARBA AND MARVIN SINGER.

THE UNDERFRAME.—PART II.

Synopsis.

ARRANGEMENT OF UNDERFRAME MEMBERS.

FORM I.

The underframe is the great vital feature of the vehicle. Upon it depends more than upon any other members the success or failure of the design. This fact has been emphasized in the previous articles wherein consideration has been directed to the beneficent results accruing from the employment of the best engineering ability and the utilization of all the time necessary to the proper detail design of members and connections so as to produce a frame of most rational design and of structural rigidity. Should all the methods of load transferrence be dealt with in one chapter the various measures taken for detail solution would overlap to such a degree that the whole, though homogeneous, would be confusing.

The first steel cars of any account to be built in America were designed in accordance with the form of framing to be discussed in this article (Form I). The sides of the car form a girder of great depth, compared with that of the centre sills, and, as its vertical rigidity is great, it is utilized as the load carrier. Concerning this form the following paragraph quoted from our former article is pertinent:

"*Theoretically* the first form is not found in practice, as it would mean that there were no centre sills whatever, and that the whole superstructure and floor loads were transferred to the side sills and thence through the bolster to the centre-plate. The practical working out of this form, however, shows a centre sill which is weaker than the side girder, and as a result is in effect hung from the sides at intermediate points between and beyond the bolster. Then the bolster gets all its load from the side sills with the exception of the centre floor load in the immediate vicinity. The bolster with weak centre sills is then the governing feature of this form."

FIELD OF USEFULNESS.

(*a*) *Type of Service.*—The choice of the prime mover is a great factor in establishing the form of car framing most suitable for use in any specified service. This is evident from the fact that for a train of equal strength the resistibility of carrying vehicles should be on a par with the motive unit.

Lines operated by steam or electric locomotives are as a consequence not suited for equipment designed with an underframe of Form I and there is left for it but one field of usefulness in train service. Multiple unit control, which is admirably adapted to a service demanding severe schedules, frequent stops, and short headway, presents conditions suited to this type of car. To enhance the efficiency of this system of operation the cars must be of light construction and withal of a strength capable of absorbing the loads occasioned in the service or hazard of such operation. This form of car is even then only applicable to those lines where passenger and freight traffic are separated and where future conditions do not indicate any decided increase in weight or speed of the trains.

(*b*) *Types of Cars.*—From the essential and fundamental features of this form it is impossible to economically construct types of cars having the side girder cut by side entrances. It is, as a consequence, not adapted to postal, postal storage, baggage or combined cars or for side entrance passenger coaches. Various expedients, however, have been resorted to in an endeavor to carry the load over the break in continuity of the main load carrying girders. The side girder may be fish bellied at this point, or indeed may be of such a form throughout its length. This method gives a very undesirable addition of weight. For very light construction the loads can be carried across the door opening at the top by designing the posts and diagonal bracing for this purpose. This also adds more weight for a given strength. There is a possibility of locally reenforcing the centre sills in the region of the doors and then transferring the loads to the centre sills and back again to the side sills before the bolster is reached. The necessity of resorting to these expedients and the weight added being useful but locally and for a single purpose points out the conclusion that this form is not suitable for side entrance doors and that Form II should be chosen for that purpose. Here each pound added to the centre sills not only serves to help support the vertical lading but takes its share of the horizontal blows of service.

OPERATING CONDITIONS.

The studies which it is necessary to make before actual designing begins is not as much a car designer's work as that of the electrical and operating departments. This work is much simplified upon a line which is established and for which the equipment is to supersede cars now in regular service. In such a case the records of operation and accident furnish the most reliable data upon which to base the requirements to which the car designer must make his car conform. On the other hand, when a road is but contemplated and all the elements of the basic study are founded upon conjecture and problematical estimate the results are much less reliable and require more thought in being taken care of.

Character of Traffic and Schedules.—The beginning of these studies is to be found in the traffic conditions of the region feeding the common carrier and the future development of such traffic. The results or deductions are based upon the loads to be hauled, the character of the right of way and the schedule conditions. The complications arising from a mixed freight and passenger service need no consideration where Form I is to be used, as we have limited its field of usefulness to only those lines operating single cars or mutiple control passenger trains.

The loads hauled and schedule conditions govern the limitations concerning the character of the trains, the number of trains, speeds and headway, ingress and egress facilities, length of cars, and all features tending toward making for attraction to the traveling public.

The facilitation of traffic with a conservation of operating

economies is generally the primary object in electrification. There are, however, a few cases where this motive power has been required for other reasons. It follows that the cars must be constructed to further the ends of augmenting travel if the beneficent results to be secured from an increased revenue train movement by a superior type of power are to be obtained.

Truck Limitations.—Truck limitations are the governing conditions upon which maximum motor sizes are based. With the present designs of motors and wheel base governed by track conditions, with the necessity for bolster space, it is not feasible to use larger than 200 horse power per driving axle. An inspection of the clearance limits of the best commercial railway motors reveals the fact that to provide for motor leads being taken over the motor cases and leave suitable clearance there must be a minimum height of 40 inches from the rail to the under-side of the centre sills. The truck bolster is not raised higher than in ordinary trucks which produces the necessity of providing a very deep centre plate on the body of the car or on the truck. If the deep extension be down from the centre sills the motor torque acts with a long arm and the tendency to set up a bending strain in these sills is considerable. On the other hand if the centre plate extend upward from the truck bolster its tilting action is much increased over and above that due to inertia forces and the truck action is poor. This is at once evidenced in discomfort to the patrons.

Unknown Factors.—Apart from its destructive influences upon the track, the gyroscopic action of the motors has a tendency to resist the proper curving of the truck. This resistance throughout the length of the curve and upon squaring on the tangents is not only a cause of disagreeable vibrations in the car body but has its effect in the imposition of repeated strains on the underframe for which no consideration has been taken. These forces together with the inertia forces of the body are instrumental in the working of any defective riveting and ultimately throwing it askew, even if not to such a degree as to be of marked import for ordinary running, it will enhance the destructive consequences of impacts. There are many factors tending to place a complicity of strain upon the underframe for which it is impossible to secure a just approximation of the value or effect. The quality of workmanship put into the vital portions of the framing and high grade of material will assuredly take care of whatever secondary stresses arise if the loads in both vertical and horizontal planes be taken at a maximum and the specification clauses covering strengths in our previous article on the underframe be followed with the recommendations given therein. It is understood, of course, that the value of allowable end shock is not a constant and varies with the hazard of operation and inherent energy of the moving units.

As to just what strength is required it is impossible to state for all cases in general. Proper reliability must be based upon careful preliminary studies and will be found to be of a changing value.

Known Factors.—All the features noted in the preliminary investigations have a direct effect upon the underframe members. The means provided for rapid loading and unloading of passengers to reduce station stops on short headway determine the choice of platform, vestibules, door arrangement, character of seating and even length of car to a certain degree. The seating capacity together with the size of superstructure permitted by clearance diagrams gives the designer the value to be allowed for lading and a figure he dare not exceed in weight per unit of length for the complete car. This is usually found to be specified before the electrical equipment is chosen. The size of motors has been referred to as placing a lower limit on the centre sill sections. An upper limit is given to the possible height of section by the height and character of station platforms where cars use no steps or combination of straight floor and steps. This we have not found in any case to exceed 53 inches.

All the space between the lower limit of 40 inches and this top limit is not available for centre sill depth, as the flooring will take up from an inch to two inches on top of the sills.

The heavy voltages in use and the liability of serious injury from the heat which may be generated in an accident or even a local derangement of the apparatus on the car, the floor must be so designed as to resist the transmission of heat to a great degree, this provision will increase the necessary depth of flooring beyond what carrying capacity and sound deadening qualities demand. The underframe members should be constructed in detail with an eye to provision for the attachment of the apparatus which will be necessary to complete the car equipment, and in this attachment the heaviest pieces should be placed as near as possible along the centre line of the car to minimize the rolling action of the body and toward the end of the car away from the motor truck, so as to dampen the whipping action in the curving of a unit, the one end of which carries a great preponderance of weight. The question of proper insulation for the electrical apparatus has been solved in a great measure for the car designers by the electrical manufacturers insulating the pieces of apparatus within their containing cases and there need be no further consideration of that subject.

Determination of End Shock.—The cars built of this form of underframe are intended for load carrying conditions which are much similar to those provided for by the early car builders. The line of demarkation is to be noted in the necessity for centre sill construction to provide for end shocks. The character of these sills is dependent upon the probability of collision and the extremity of the destructive forces accompanying such impact. Frequency of trains and short headway, together with the character of the service, the use of the same tracks by both steam and electricity, the type of signals, condition of equipment and personnel of the service, all contribute or detract from this probability. The maximum of the destructive forces resulting from two trains endeavoring to pass each other on the same track is determined by the mass and the impinging velocity of the moving units. Evidently there is such a case that the probability of collision or wreckage is so remote and the weights and velocities so limited as to make the use of centre sills entirely unnecessary (as for example infrequent car service on trolley lines) and opposed to this condition is that of our steam trunk lines, where the probability is ever imminent and the weights and speeds a maximum.

Thus the provisions which are made for these destructive buffing strains must be capable of standing up to the data secured from a most careful study of the conditions under which the equipment will operate. Not only must these operating conditions be determined for the present, but the future should be analyzed so that the cars may be capable of providing strength and reliability for all service contingencies liable to be operative throughout its life. This can at best be only surmised and will vary much with the locality. Much can, however, be anticipated and it is always better to err on the side of increased safety. Under metropolitan operating conditions the power is much overworked at the present time, motor overheating has become a serious problem. This looks toward the use of quadruple equipment together with increased possibilities for speed and the added weight for the electrical apparatus. Then also the possibility of trunk and metropolitan lines using common tunnels or tracks to a Union station must be considered. The hazard of operation, together with the kinetic energy stored in the train, is thus a basis upon which the end shocks can be provided for in comparison with that found to hold good for steam service in the first underframe article.

Considering the features of this underframe, *i.e.*, a weak centre sill construction and rigid side girder, it is apparent that it is good only for nominal end shocks. For such service this car can be constructed lighter for a given strength than any other form. There is a point in the series of values of buffing loads for a car of given length where the economy in weight of the Forms I and II is identical, below this point the first is preferable and above it the second.

This form of underframe is hence at its best when the maximum end shocks coming upon it are not of a severity exceeding those which occur in steam service with the most careful handling. It will require but a fair sized motor train operating at good speed to produce the maximum of strain, but for purposes of illustration we shall assume to design the sectional areas re-

quired in the main members for a coach to operate under the conditions for which we have previously noted this form was most useful. That is for a road which handles passenger electric multiple control trains exclusively with schedule speeds of not more than 45 miles per hour and the maximum trains run in either express or local service to be of eight cars. The weight of these cars to be 70,000 pounds for trailers and 75,000 pounds for motors of approximately 52 feet long over platform and end sills.

In this exposition we aim to show how to use the loads to find the stresses for any car of this form, and as a consequence we shall not take into account the possibility of future developments in operation of the road. These developments would not change the character of the strains but they would alter their intensity. The degree of such change fluctuates with so many variables, as before noted, that a consideration of them would not help the discussion of how strains of this character are resisted and the stress in the members produced by such resistance. The local trains weigh more than the express trains in this service for the reason that the proportion of motor cars to trailer cars must be increased so as to obtain sufficient acceleration to make time with the very frequent stops required. The express trains travel with greater schedule speed and from an examination of such trains on existing lines we find that the kinetic energy of the two trains is about equal and that of a local excursion train of double the number of cars is not much in excess of the value of the express.

The kinetic energies of the heavy steam express trains on several prominent trunk lines operating at schedule speeds ranges anywhere from 50,000,000 to 120,000,000 foot-pounds, for which trains we have advocated a shock of 500,000 pounds static for buffing.

The kinetic energy inherent in an eight motor car train operating between 40 and 45 miles per hour is about 50,000,000 foot-pounds. The factors of weight and speed having been taken into account in both steam and electric service and the short headway in the latter making for as much possibility of operating accidents as are pregnant in the former, it would seem proper to assume that the end shocks that should be provided for in the latter case would be 5/12 of 500,000, which is about 200,000 pounds. This will illustrate exactly what is meant by the relative value of the quality of reliability, and other conditions being equal the end shocks may safely be assumed to vary from 0 to a maximum of 500,000 pounds (recommended from Lake Shore tests), and that the degree of end shock be chosen according to the ratio of kinetic energies.

ARRANGEMENT OF UNDERFRAME MEMBERS.

The diagram, Fig. 1, illustrates the disposition of the members of the framing but does not represent our ideas of detail design to stand up under the assumed end shock.

The centre sills are composed of shallow I-beams, the largest and heaviest section for the 6-inch beam being assumed. They are to be continuous from platform to platform and rest upon transverse supports to the side girder. The body end sill is the first support, next would come the bolster and between the two bolsters these supports are placed at the main posts, which in turn are spaced according to the window arrangement most convenient to the passengers and character of seating. The centre sills are then a continuous beam with 10 spans. The character of the end construction determines the values of bending stresses in the last span at each end and affects the moment in the spans contiguous to them. If the vestibule is made strong enough in the hood to act as a cantilever to help support the platform, then the end sills in this region are loaded with a uniform load, which is a maximum when the car is filling up or emptying and the platform is full of passengers. Opposed to this design is that in which the end sills get half the platform load at the platform end sill; this will increase the end bending moment in the end spans. In the former case the end span is supported and in the latter is overhanging. The supported end is the best condition and to secure it the end roof construction must be designed for good vertical rigidity and stiffness. This will in effect transfer all this load to the side girder through the body end construction and end sills. There is no other way to take care of it and provide for platform doors and steps. The diagram does not show steps, but their use is necessary for nearly all service conditions.

Centre Sill Lading.—The character of the loading which comes on these beams is a combination of, first, the uniform lading due to dead weight and passenger lading, and, second, that from the uniform load, equivalent in effect to the end shock or, if no end shock is to be provided for, the eccentric tension or compression due to the motor torque.

The determination of the reactions at the supports or transverse beams are not readily found in this type of beam (continuous) and difficulties are interposed to the finding of the shearing stresses and moments at the various sections which should be investigated. A positive check upon all the theory connected with these sills is afforded by an application of the general principles of the equation of equilibrium between external and internal forces and moments. These fundamental theories must hold as well as those for shear and moments. Stated concisely these are, *"that for any section the shearing stresses and moments are respectively equal to the algebraic loads and moments on either side of that section."* It is customary to consider the left side in calculating. Not only do these afford a check, but they are used to find the general formulæ applicable to any given case.

Each mid-span of this girder is in the same condition as if it had both of its ends overhanging and the two end spans at the platforms with but one end overhanging (for the supported condition, otherwise it would be in the position of a beam with a support in the central region).

Using a standard structural shape for the centre sills with a constant cross section and depth, the values of moment of inertia and modulus of resistance are equal throughout the sills if the supports are at the same level. This simplifies the application of the theory of three moments to the case in hand. The question as to whether it is advisable to use a light box girder of the same weight as two simple rolled shapes will depend to a great extent upon the character of the climate and atmosphere where the cars are intended to run. With the strength disposed in such a manner all the members are very thin and a corrosive atmosphere will shortly seriously impair their usefulness, since a small amount of corrosion represents such a large loss of percentage area and strength. No matter what the character of the lading or the form of the beam the theorem of "three moments" will apply to it.

THEORETICAL DISCUSSION OF CENTRE SILLS.

Continuous Beams.—The treatment of this theorem is very unsatisfactory in the majority of text and reference books upon the "Mechanics of Materials" and "Girder Design." The lack is due to the fact that with few exceptions the only beams treated are for uniform loads and lengths for all spans, so that the application to any special beam other than found therein requires the working out of a suitable formula to suit it. The derivation of the completed general formula will be found for the centre sill assumed, and the remainder written by analogy to fit each span.

The method of the solution is to first find the equation of the elastic curves for any section and its adjacent span which multiplied by the product of the coefficient of elasticity into the moment of inertia will be a measure of the bending moment. These two differential equations when integrated once and the constants of integration determined represent the slope of the tangent to the elastic curve. Now since the curves have been found for two adjacent spans it follows that over the point of support between the spans the curves must have a common tangent. The next step is to evaluate the tangent equations for the ordinates of this point of tangency and equate the two equations which are now identical and the solution of this resulting equation gives a result showing the relation between the three moments, the two span lengths and the loading upon each length. The problem is complicated somewhat because the equations contain

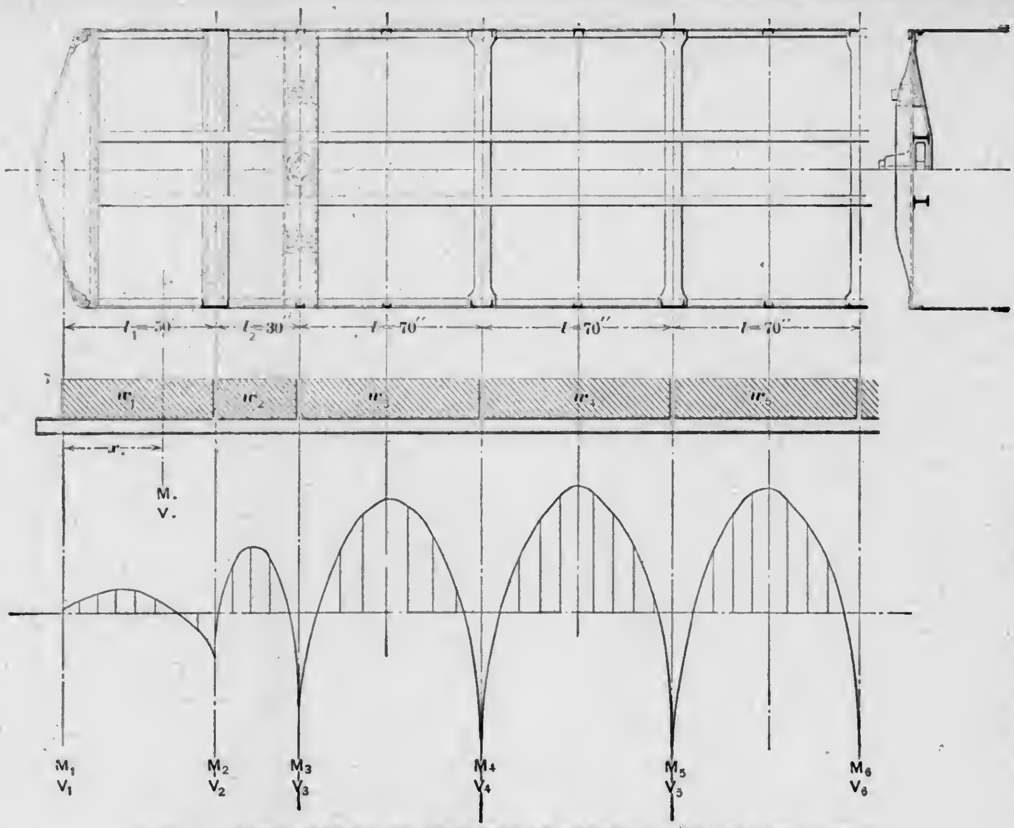


FIG. I.—ARRANGEMENT OF UNDERFRAME MEMBERS AND MOMENT CURVES.

expressions of the vertical shearing stress at the supports and it becomes necessary to find the moments at the supports to eliminate it in the tangent formula.

Consider the first two spans at the left end of the diagram. The moments, reactions, shears, lengths, and weights are designated. For any curve of bending, the general formula expressing the relation between the bending moment, physical properties and disposition of the material and curve is

$$\frac{d^2y}{dx^2} = \frac{M}{EI}$$

or

$$EI\frac{d^2y}{dx^2} = M \quad \ldots\ldots 1.$$

Now for any section at distance x from the end, the general law of moments will give

$$EI\frac{d^2y}{dx^2} = M = M_1 + V_1x - \tfrac{1}{2}w_1x^2 \quad \ldots\ldots 2.$$

This equation upon being integrated and the constants of integration being found from the relations that $y = o$ when $x = l$, there will result

$$24EI\frac{d^2y}{dx^3} = 12M_1(2x - l_1) + 4V_1(3x^2 - l_1^2) - [w_1(4x^2 - l_1^3)] \quad \ldots\ldots 3.$$

By analogy we can write for the second span

$$24EI\frac{dy}{dx} = 12M_2(2x - l_2) + 4V_2(3x^2 - l_2^2) - w_2(4x^3 - l_2^3) \quad \ldots\ldots 4.$$

These are the two tangent slopes which must be identical when $x = l$, in the first case and when $x = o$ in the second. This substitution having been made (3) becomes

$$24EI\frac{dy}{dx} = 12M_1l_1 + 8V_1l_1^2 - 3w_1l_1^3 \quad \ldots\ldots 5.$$

and (4) becomes

$$-24EI\frac{dy}{dx} = -12M_2l_2 - 4V_2l_2^2 + w_2l_2^3 \quad \ldots\ldots 6.$$

The signs have been changed, due to the difference in character of the moments, but the numerical value remains the same.

These equations must be evaluated for the shears V_1 and V_2 before they are in shape to use, as we wish. The general theory of shears gives the result for shear v at any section x.

$$V = V_1 - w_1x \quad \ldots\ldots 7.$$

V_1, from the above theory, represents the algebraic sum of all the loads on the left of the section. These loads have a moment about the section x depending upon how far the graphical resultant of those loads is removed from x.

V_1 is the resultant and the arm of its action to the left of the point of support can be assumed to be x_1, then the moment of these loads about x is

$$V_1(x_1 + x)$$

$$M_x = V_1(x_1 + x) - w_1x\tfrac{1}{2}x$$

$$= V_1x_1 + V_1x - \frac{w_1x^2}{2} \quad \ldots\ldots 8.$$

Now from definition $V_1 x_1$ is the value of the moment at left support and as such is equal to M, shown in the diagram, hence formula (8) becomes

$$M_x = M_1 + V_1x - \tfrac{1}{2}w_1x^2 \quad \ldots 9.$$

This shows that to find M_x it is necessary to know V_1 and M_1. Now suppose x to be taken equal to l, which will cause M_x to equal M_2 and formula (9) becomes

$$M_2 = M_1 + V_1l_1 - \tfrac{1}{2}w_1l_1^2 \quad \ldots 10.$$

This when transposed gives a value of

$$V_1l_1 = M_2 - M_1 + \tfrac{1}{2}w_1l_1^2 \quad \ldots 11.$$

By analogy the values of V_n may be written

$$V_n = \frac{M_{n+1} - M_n + \tfrac{1}{2}w_nl_n^2}{l_n} \quad \ldots\ldots 12.$$

Substituting values of V_1 in equation (5) and V_2 in equation (6) and equating the results there is found

$$M_1l_1 + 2M_2(l_1 + l_2) + M_3l_3 = \tfrac{1}{4}w_1l_1^3 - \tfrac{1}{4}w_2l_2^3 \quad \ldots\ldots 13.$$

which in its general form for any span (n) is

$$M_nl_n + 2M_{n+1}(l_n + l_{n+1}) + M_{n+2}l_{n+2} = \frac{w_n}{4}l_n^3 + \frac{w_{n+1}}{4}l_{n+1}^3 \quad ..14.$$

These formula show how the bending moment at any support is connected with those on either side of it.

The bending moments at the supports are thus determined, it remains to find that for the middle of the span. Considering equation (9) written in a general form for span (n) from left end and x to be taken for the middle ordinate or $x = \frac{l_n}{2}$ then

$$M_x = M_n + V_n\frac{l_n}{2} - \frac{w_n}{4}l_n^2 \quad \ldots\ldots 15.$$

Now from (12) substitute the value of V_n and simplify when there will result

$$M_x = \frac{M_n + M_{n+1}}{2} \quad \ldots\ldots 16.$$

which denotes that at the middle of any span the bending moment is a mean of that at either end.

In the diagram there are 10 spans and 11 supports with 9 unknown moments. Nine equations can be written by analogy from formula (14), but only the first five of them are necessary for solving this problem, since the following relations between the quantities hold from the construction. These are $l_3 = l_4 = l_5 = l_6 = l_7 = l_8 = l_9 = l$. $l_{10} = l_2$ and $l_{11} = l_1$.

$M_1 = M_{11} = O$

$M_2 = M_{10}$

$M_3 = M_9$

$M_4 = M_8$

$M_5 = M_7$ and all values of w are equal.

(*b*) *Struts.*— The design of columns rests on a much less rational basis than beams. Euler's formula is theoretically correct in giving the load which causes rupture by lateral binding, but is only true for columns where the slenderness ratio is large. Merri-

man cites Rankine's formula as the peer of any of the column formulæ which have been developed to investigate the action of columns when stressed within the elastic limit. This column formula

$$S = \frac{P}{a}\left[1 + \vartheta\left(\frac{l}{r}\right)^2\right]$$

when solved for values of

$P = 200{,}000$ pounds
$a = 2 \times 5.07 = 10.14$ sq. inches
$\vartheta = \frac{4}{25000}$
$r = 2 \times 2.27 = 4.54$ inches

will give a value of S, which is beyond the ultimate strength of the centre sill beams. This is the condition that would have to be provided for if the connection between the centre sills and the side sills were not perfectly rigid and stronger than the beams themselves in their members. Hence the method of using weak sills with such an end shock is to reduce the slenderness ratio and approximate as closely as possible to the condition of a series of short struts or even compression pieces. To do this we shall consider the connections as we have said they must be and solve for struts of lengths 70 inches, 50 inches and 30 inches.

The stress is a combination of the direct and bending stresses. This portion of the stress due to bending, which is $\vartheta \frac{l^2}{r^2}$, we propose to use as a measure of uniform load which produces a bending action in the centre sills at right angles to the uniform lading of the car body. This operation is necessary to secure a just appreciation of the forces which come on the side sills in a horizontal plane. This condition holds when the transverse supports are firm in a combination of either tension or compression and flexural stresses and the centre sills have their greatest least radius of gyration about a vertical axis, as is true in this case.

(*To be continued.*)

INSTALLATION OF DR. W. F. M. GOSS.

The formal exercises incident to the installation of Dr. W. F. M. Goss as Dean of the College of Engineering of the University of Illinois, occurred February 5 in connection with the formal opening of the graduate school of the University. The exercises included two sessions and a tour of inspection through the laboratories.

The morning session began with a brief address by the president of the University, Dr. Edmund J. James, introducing the chairman of the session, Prof. James M. White. Addresses were delivered by Prof. Ira O. Baker, describing some significant events in the development of the college, with which he has been identified for more than thirty years. Mr. William L. Abbott, president of the Board of Trustees, briefly discussed the standing of the technical graduate in the engineering profession. Following this the formal installation address of Dr. Goss entitled the "State College of Engineering," was delivered.

The afternoon session included an address by Mr. Robert W. Hunt on "The Value of Engineering Research," and an address by Mr. Williard A. Smith, on the "Need of Graduate Courses in Engineering."

Between the sessions a trip of inspection through the several laboratories took place. Special interest was shown by the visitors in the electric test car; the railway dynamometer car, and the 600,000-lb. testing machine for work on reinforced concrete, which are installed in these laboratories. A large number of guests were present, including representatives of all the more important educational and scientific societies and technical journals.

MARCH MEETING OF THE A. S. M. E.—At the next regular monthly meeting, to be held in New York on the evening of March 10, a paper on the "Steam Path of the Steam Turbine" will be presented by Dr. Charles P. Steinmetz.

LOCOMOTIVE SMOKE STACKS.

By W. E. JOHNSTON.

The Master Mechanics' tests on exhaust pipes and nozzles made at Purdue in 1896 showed the form of the exhaust jet for a 4¼" nozzle very clearly and if further tests were made with nozzles of different diameters, it is reasonable to suppose that the form of the jet from all nozzles of the same type would be similar and that the diameter of the jet at any point would be proportional to the diameter of the nozzle. Also, since the diameter of the jet increases in a definite manner as it leaves the nozzle, some expression can be derived to show the diameter of the jet at any point. Further, since the jet produces the vacuum in the smoke box, it should be possible to derive a formula for stack diameter, based on the nozzle diameter and the distance from nozzle to the choke of a taper stack or some corresponding point in a straight stack.

A comparison of a few boilers of recent design for Mikado, Consolidation, Pacific, American and six-wheel switch engines shows that the Master Mechanics' formulæ will give quite different results from one based on nozzle diameter and distance from nozzle to stack.

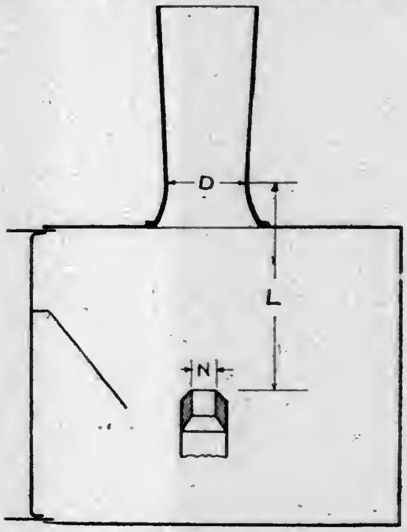


FIG. I.

It is evident that the smoke box may be varied in any manner, so long as its variations in shape do not restrict the flow of gases from the flues to and around the jet and to the base of the stack. This conclusion is confirmed by the results of the Master Mechanics' tests of 1906.

It is the purpose of this article, therefore, to present the development of new formulæ for stack diameters, using the data obtained in the tests of 1896, 1903 and 1906 as a basis.

TAPER STACKS.

The tests of 1896, in addition to showing the form of the jet, showed that the best distance for a 4¼" nozzle from the choke of a 14" taper stack was about 47", using a draft pipe. The best results for the 1903 tests are shown in Table I. and Fig. 1, using the same references for nozzles as in the Master Mechanics' Committee's report.

TABLE I.

Nozzle.	"D" Best Results.	L.	$\sqrt{L}$.	$\frac{D}{4\frac{1}{4}\sqrt{L}}$
1	14¾"	55"	7.42	.47
2	13¾"	50"	7.07	.46
3	13½"	45"	6.71	.47
4	12¼"	40"	6.32	.46
5	11¾"	35"	5.92	.47
6	11¼"	30"	5.50	.48
7	10"	25"	5.00	.47
Average				.47

By trial, it was found that the diameter of the best stack varied at a less rate than the distance "L" and that this variation was practically proportional to the square root of this distance; that is, $\frac{D}{4\frac{1}{4}\sqrt{L}}$ is constant. Assuming that the diameter of the best stack is proportional to the diameter of the nozzle, the

equation using the average value of $\dfrac{D}{4\frac{1}{4}\sqrt{L}}$ is $D = .47\ N \sqrt{L}$.

Where N = diameter of nozzle ($4\frac{1}{4}''$ in these tests).

L = distance from nozzle to choke of stack in inches.

D = diameter of stack.

The results of the 1906 tests were not plotted in the diagrams included in the report of the Master Mechanics' Committee to show the variations in diameter of the best stack with variations in the distance from nozzle to choke. Diagrams Figs. 2 to 9 have, therefore, been prepared, showing the results of the tests with 3lb, 4lb and 5lb back pressure as far as shown in the

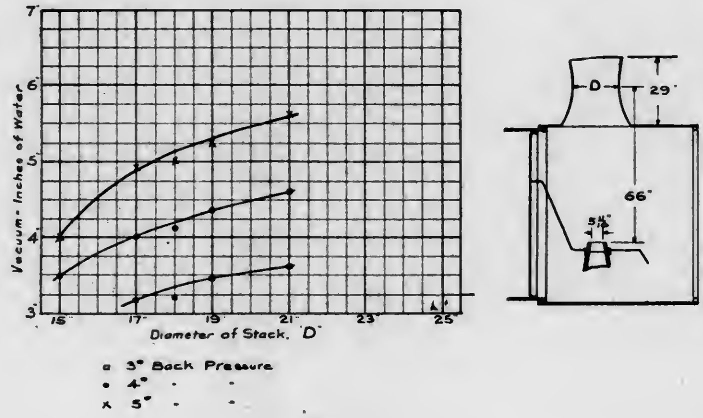


FIG. 2.

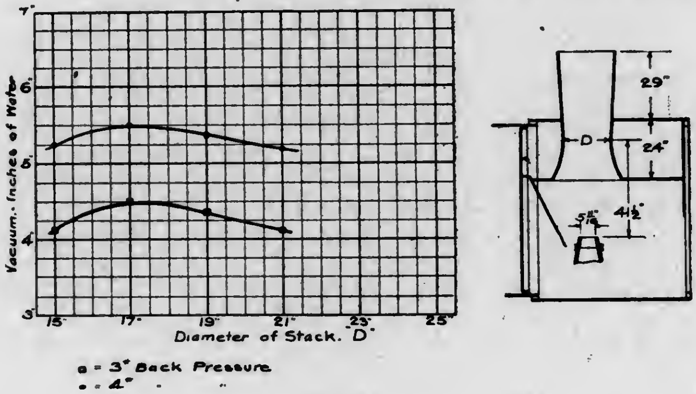


FIG. 6.

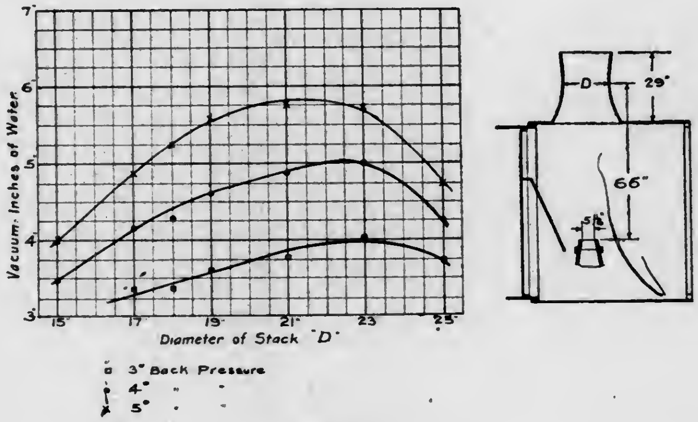


FIG. 3.

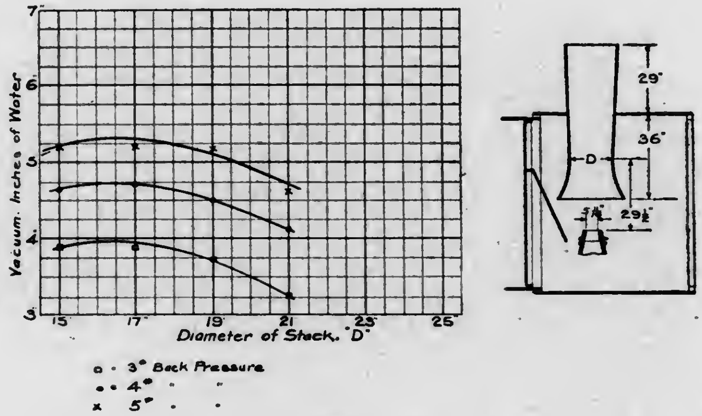


FIG. 7.

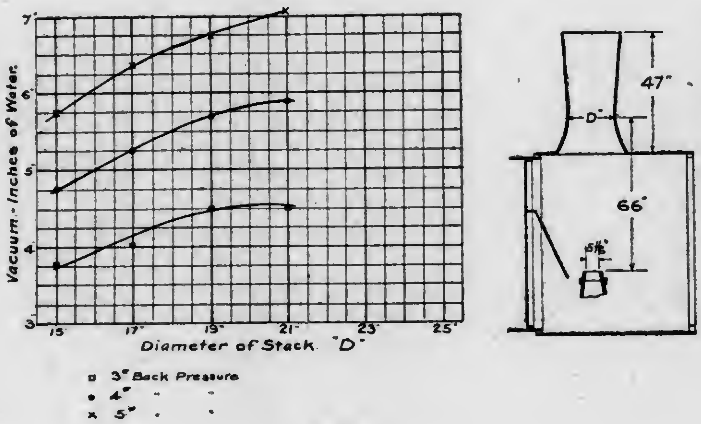


FIG. 4.

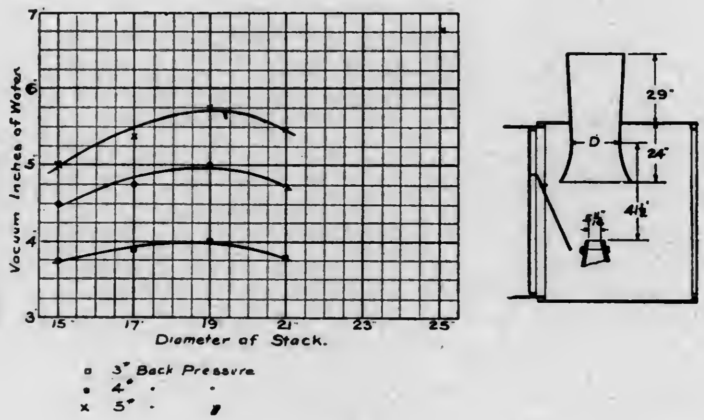


FIG. 8.

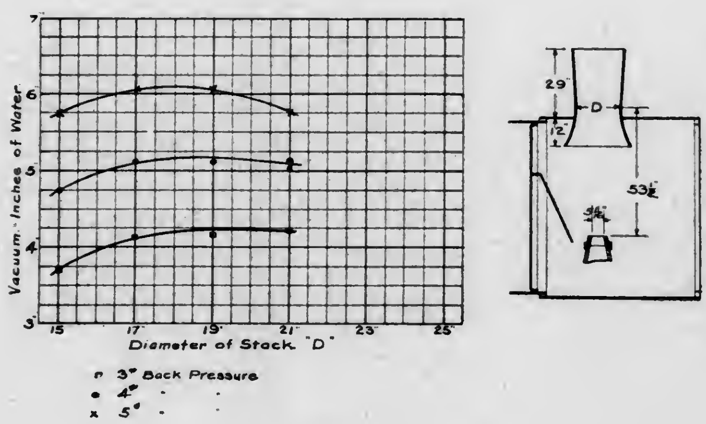


FIG. 5.

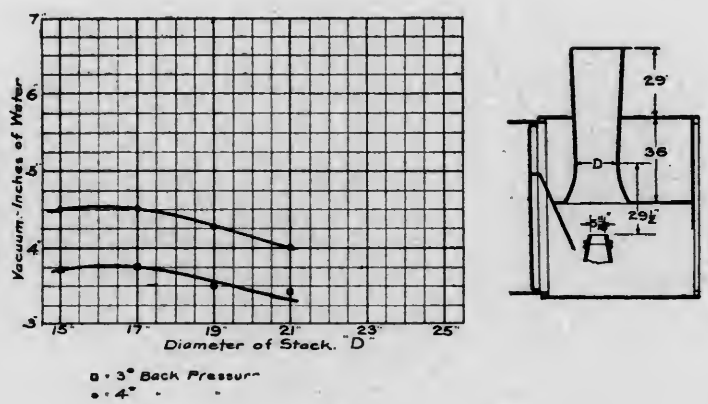


FIG. 9.

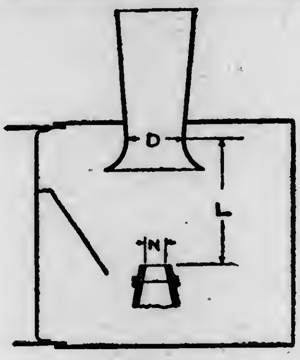


FIG. 10.

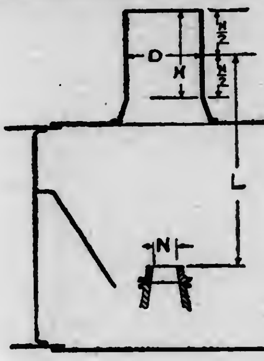


FIG. 11.

report for plain front ends, Series No. 2 to No. 9.

From these diagrams Table II. and Fig. 10 have been taken.

TABLE II.

Series.	"D" Best Results.	L.	L.	D / 5 11/16 $\sqrt{L}$.
2	Greater than 21"	66"		
3	23"	66"	8.12	.497
4	Greater than 21"	66"		
5	19"	53½"	7.32	.456
6	19"	41½"	6.44	.518
7	16"	29½"	5.43	.517
8	17"	41½"	6.44	.464
9	16"	29½"	5.43	.517
Average				.49

The equation for these tests is then $D = .49\ N\ \sqrt{L}$, derived in the same manner as for the 1903 tests. Referring again to the tests of 1896, the equation derived similarly is $D = .48\ \sqrt{L}$.

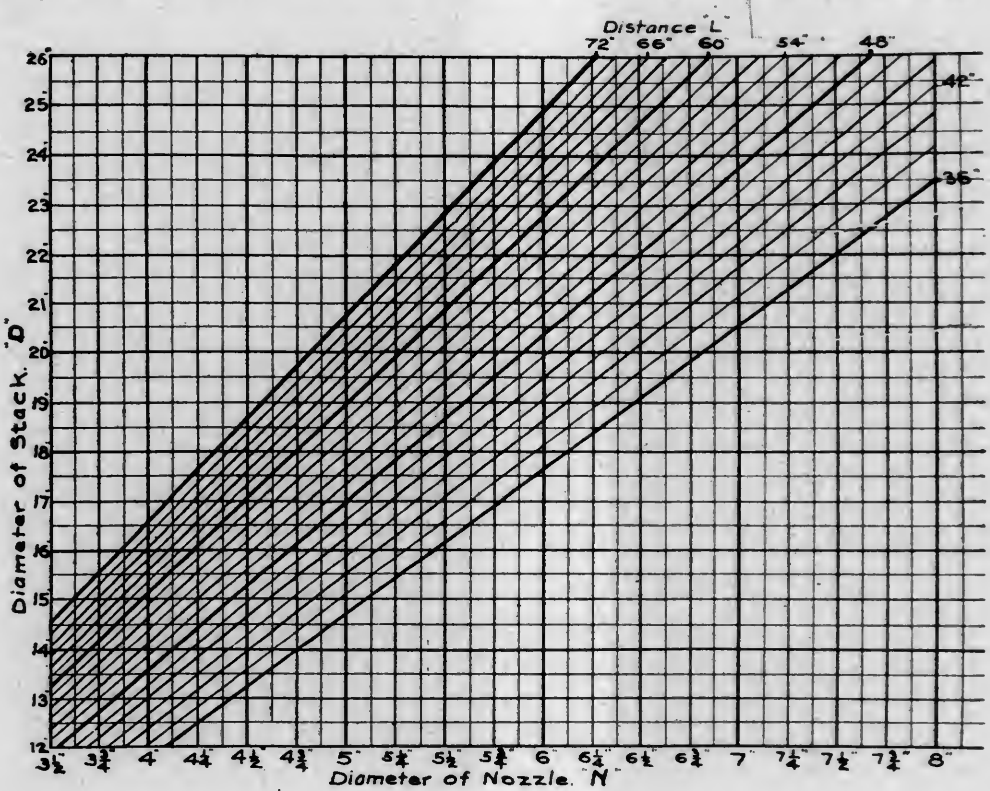


FIG. 12.

The larger constant in the formula for the 1906 tests is probably due to the form of the nozzle. The 1903 nozzle is like Style "X," shown in the 1896 report, while the 1906 nozzle is like Style "Y"; Style "X," as stated in the 1896 report, gives less spread to the jet and would, therefore, require a slightly smaller stack than Style "Y."

The close agreement between the equations for the three years would seem to be sufficient proof of the reliability of the formula for general use.

Fig. 12 shows a diagram for conveniently finding the diameter of choke for taper stacks, based on the equation $D = .49\ N\ \sqrt{L}$.

STRAIGHT STACKS.

It is reasonable to suppose that the formula for straight stacks would be similar to that for taper stacks. In this case there is no definite place corresponding to the choke of a taper stack which may be taken as a measuring point.

Table III. and Fig. 11, however, show the results for the tests of 1903, obtained by taking "L" to the middle of the straight portion of the straight stacks and would seem to indicate that the formula $D = .49\ \sqrt{L}$ would give satisfactory results for straight stacks also.

TABLE III.

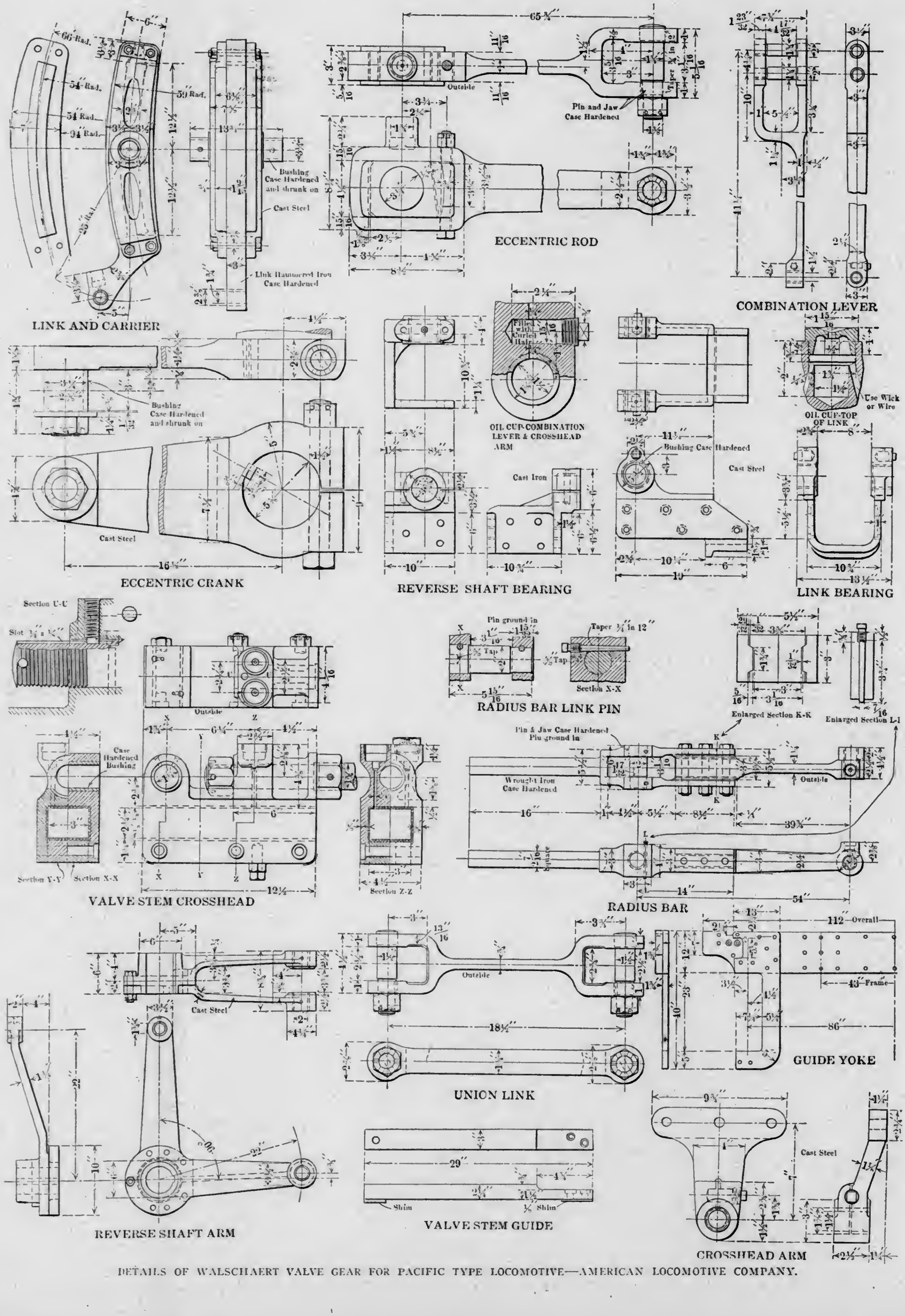
Length of Stack.	Nozzle Number.	"D" Best Results.	L.	$\sqrt{L}$.	D / 4¼ $\sqrt{L}$.
26½"	1	Greater than 15¾"	60		
	2	15¾"	55	7.42	.500
	3	14¼"	50	7.07	.474
	4	13¾"	45	6.71	.483
	5	13¼"	40	6.32	.493
	6	12¼"	35	5.92	.487
	7	11¾"	30	5.48	.503
36½"	1	Greater than 15¾"	65		
	2	Greater than 15¾"	60		
	3	15¾"	55	7.42	.500
	4	14¾"	50	7.07	.491
	5	14¼"	45	6.71	.500
	6	13¼"	40	6.32	.493
	7	11¾"	35	5.92	.467
46½"	1	Greater than 15¾"	70		
	2	Greater than 15¾"	65		
	3	Greater than 15¾"	60		
	4	15¼"	55	7.42	.484
	5	14¾"	50	7.07	.491
	6	14¼"	45	6.71	.500
	7	13¼"	40	6.32	.493
56½"	1	Greater than 15¾"	75		
	2	Greater than 15¾"	70		
	3	Greater than 15¾"	65		
	4	15¾"	60	7.75	.478
	5	15¾"	55	7.42	.500
	6	14¾"	50	7.07	.491
	7	13¾"	45	6.71	.483
Average					.49

Inasmuch as the variation in diameter of the stack is from two and a half to four times the variation in nozzle diameter, considerable care will be necessary in using this formula on new designs to determine the diameter of the nozzle reasonably close in advance for the particular conditions under which the engine is to operate. On old engines, the problem is simple, of course, as the size of the nozzle can be measured readily and the stack diameter can be taken from Fig. 12.

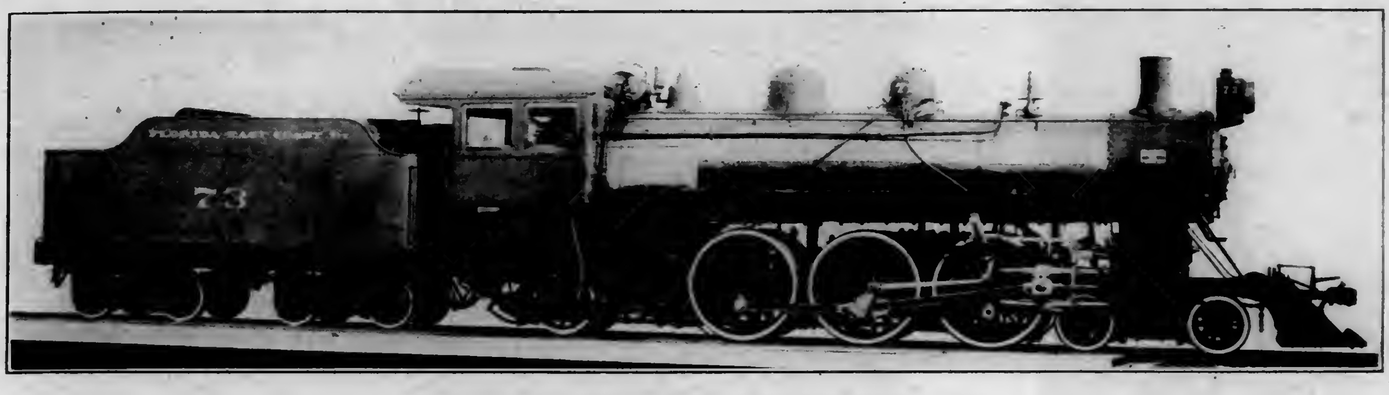
It should be noted that this formula is based on front ends without draft pipes and, therefore, as determined by the Master Mechanics' Committee in 1906, will give larger stack diameters than for front ends with draft pipes, this being in accordance with their report, that the larger stack without draft pipes gave the most satisfactory results.

REQUIREMENTS OF SUCCESSFUL TRAVELING ENGINEERS.—Success and skill as enginemen are not all that is essential in a road foreman or traveling engineer—good judgment, a cool head, a temperate tongue and a "thick skin" are perhaps the best assets he can have. Without these he is not likely to possess the art of "approaching" in a satisfactory manner, the rank and file of enginemen with their various dispositions.—*Mr. D. R. MacBain before the Traveling Engineers' Association.*

LONGEST RAILWAY BRIDGE.—There is now in process of construction at Vancouver, Washington, a bridge to carry the Seattle, Portland Railway Company's line across the Columbia River, which when completed will have the distinction of being the longest bridge of its class in the world. Its total length will be 1½ miles and its width will be about 35 ft., carrying a double track. The completed bridge will comprise 47 spans. A draw span, 450 ft. long, is provided in the centre of the river.



DETAILS OF WALSCHAERT VALVE GEAR FOR PACIFIC TYPE LOCOMOTIVE—AMERICAN LOCOMOTIVE COMPANY.



PACIFIC TYPE LOCOMOTIVE WITH WALSCHAERT VALVE GEAR.

WALSCHAERT VALVE GEAR FOR PACIFIC TYPE LOCOMOTIVE.

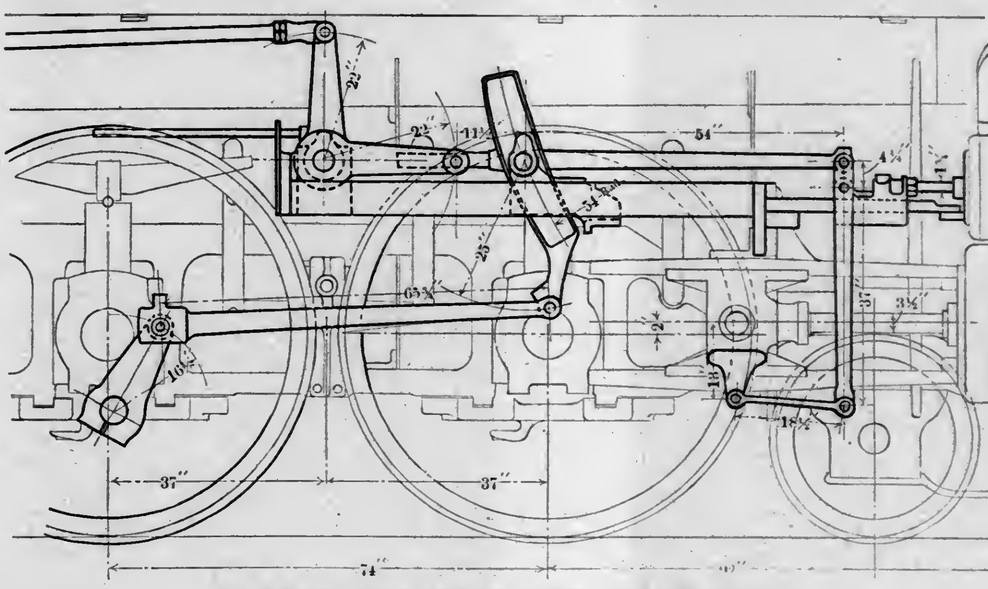
The application of the Walschaert type of valve gear to a Pacific type locomotive presents difficulties not encountered with other wheel arrangements. This, of course, is due to the proximity of the front driving wheel to the cylinder, necessitating the placing of the guide yoke very far forward and preventing its use as a support for the link. If, on the other hand, the link is placed back of the driver, being hung on an extension of the frame cross tie, as is often done with the ten-wheel type, it makes the eccentric rod so short as to introduce very serious errors of angularity. These difficulties have been solved by placing a supplementary frame outside of the front driver on which the link can be supported at the most desirable point. This construction adds considerable weight and a number of extra parts to the locomotive, but is practically the only solution of the problem.

One of the simplest and best arrangements of this gear, which has come to our notice, is found on an order of ten locomotives recently delivered by the American Locomotive Company to the Florida East Coast Railroad. These engines are of medium weight, Pacific type, having 20 x 26 in. cylinders; 68 in. drivers and weigh 196,000 lbs. total. The boiler is of the extended wagon top type, measuring 62¼ in. diameter at the front end, has a total heating surface of 2,571 sq. ft. and carries a steam pressure of 200 lbs. The design of the engine is in general the same as other locomotives of this type built by this company, many of which have been illustrated in these columns, and outside of the valve gear will be given no special mention. The double check valve on the top of the front barrel sheet is of the Phillips design, and was described on page 27 of the January issue of this journal. The general dimensions and ratios are as shown in the table at the end of this article.

The valve gear, as is always desirable, is practically all in one vertical plane, there being but 2½ in. difference between the center of the pin on the eccentric crank and the valve stem; 1½ in. of this is in an off-set in the eccentric rod and 1 in. is obtained at the connection of the radius bar to the combination lever. The valve chamber is thrown 4 in. outside the center of the cylinders, which presents no objection other than the increase in the weight of the cylinder casting and slightly longer steam passage, provided the clearance limits are not exceeded.

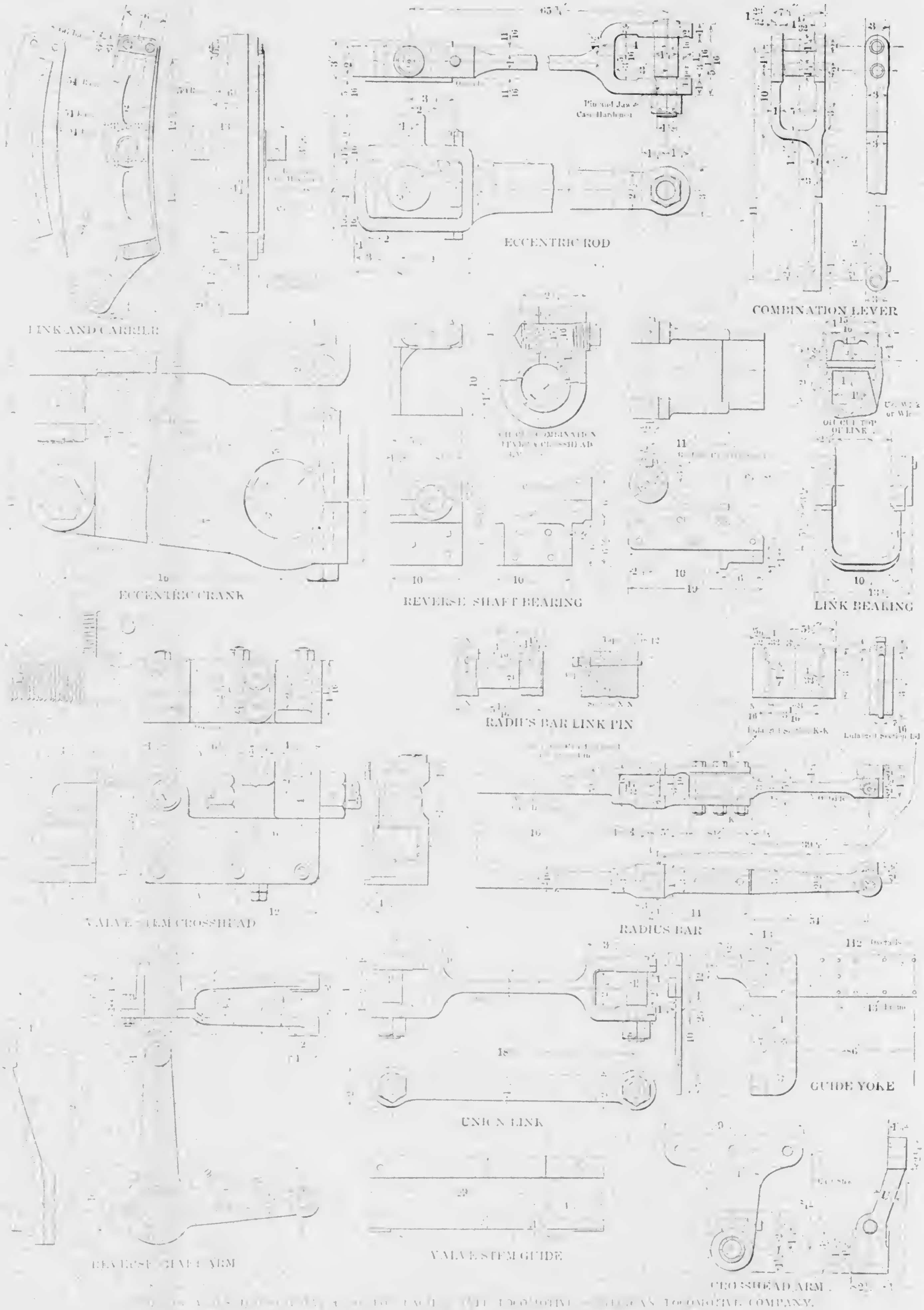
The illustrations on the opposite page show the detailed design of the more important parts of the gear. The eccentric crank is of cast steel and fits over a 5⅝ in. diameter extension of the main crank pin, to which it is secured by a 1½ in. binding bolt. The crank is split at the back and a clearance of ¼ in. allowed, so that it can be drawn tightly to a bearing by means of the bolt. The crank is maintained in its setting by a ¾ x 1 in. key and by the binding bolt fitting into a recess in the main pin, as is shown in the drawing. The pin on the end of the crank is 3¼ in. diameter, and is provided with a case hardened bushing shrunk into place, which forms a bearing for the eccentric rod brass. This method of fastening the crank to the main pin permits it to be removed if desirable by simply driving out the single binding bolt.

The eccentric rod is wrought iron and is fitted at the back end with a split brass bearing arranged with a wedge and adjusting screw for taking up wear. The forward end is in the form of a jaw for connection to the bottom of the link. This connection is made by a 1¾ in. pin, with taper fits in the rod and a counter sunk head on the inner side. The pin and the bushing in the link extension into which it fits are both case hardened. The link itself is made of hammered iron and case hardened, and is carried between two cast steel carriers, which have 3¼ in. trunnions fitted with case hardened bushings shrunk on and pinned to place. These trunnions rest in a cast steel bearing of special design, which fits between and is supported by two 1½ x 6 in. rolled iron plates extending between the guide yoke and the extension of a special frame cross tie located between the first and second pair of drivers. These plates are set at 12¼ in. centers and form a very rigid support for all of the main members of the gear.

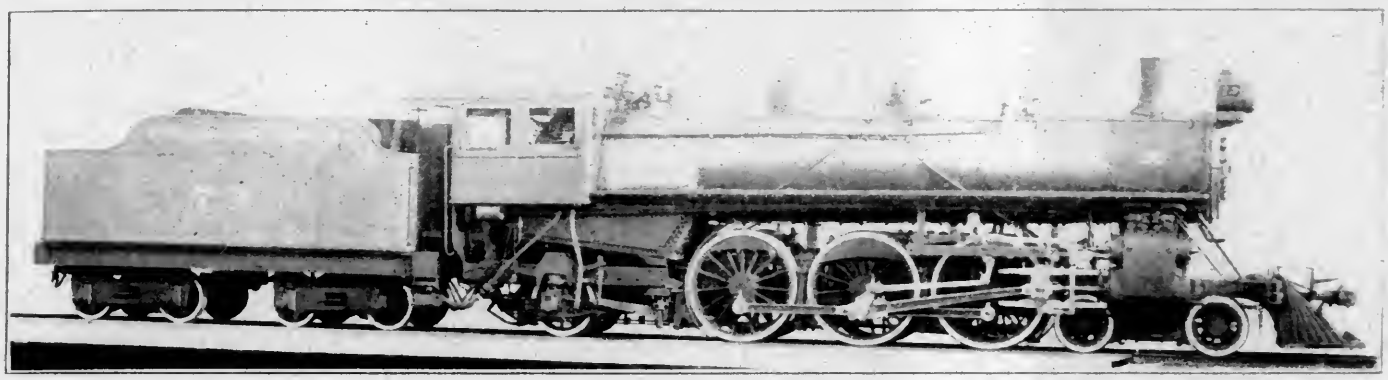


WALSCHAERT VALVE GEAR ON PACIFIC TYPE LOCOMOTIVE.

The reverse shaft is carried in bearings fastened between and to these plates at their connection to the frame cross tie. This bearing, which is shown in detail, is fitted with a cap held in place by two bolts, permitting the easy removal of the shaft. The reverse shaft arms are of cast steel in two parts, so constructed that the outer section of the arm can be removed without disturbing the shaft or inner arm. A block, having a sliding fit on



[illegible] AMERICAN LOCOMOTIVE COMPANY.



PACIFIC TYPE LOCOMOTIVE WITH WALSCHAERT VALVE GEAR.

WALSCHAERT VALVE GEAR FOR PACIFIC TYPE LOCOMOTIVE.

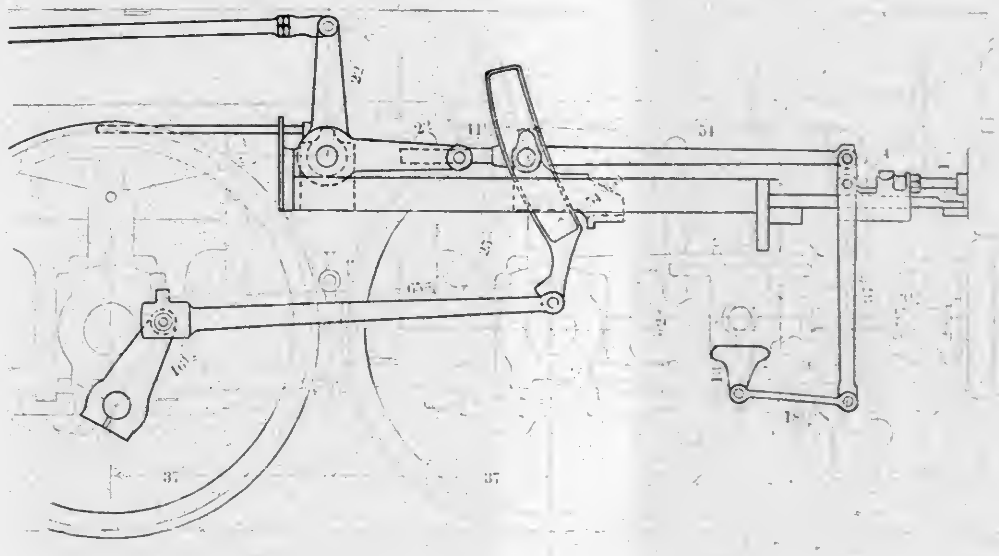
The application of the Walschaert type of valve gear to a Pacific type locomotive presents difficulties not encountered with other wheel arrangements. This, of course, is due to the proximity of the front driving wheel to the cylinder, necessitating the placing of the guide yoke very far forward and preventing its use as a support for the link. If, on the other hand, the link is placed back of the driver, being hung on an extension of the frame cross tie, as is often done with the ten-wheel type, it makes the eccentric rod so short as to introduce very serious errors of angularity. These difficulties have been solved by placing a supplementary frame outside of the front driver on which the link can be supported at the most desirable point. This construction adds considerable weight and a number of extra parts to the locomotive, but is practically the only solution of the problem.

One of the simplest and best arrangements of this gear, which has come to our notice, is found on an order of ten locomotives recently delivered by the American Locomotive Company to the Florida East Coast Railroad. These engines are of medium weight, Pacific type, having 20 x 26 in. cylinders; 68 in. drivers and weigh 196,000 lbs. total. The boiler is of the extended wagon top type, measuring $62\frac{1}{4}$ in. diameter at the front end, has a total heating surface of 2,571 sq. ft. and carries a steam pressure of 200 lbs. The design of the engine is in general the same as other locomotives of this type built by this company, many of which have been illustrated in these columns, and outside of the valve gear will be given no special mention. The double check valve on the top of the front barrel sheet is of the Phillips design, and was described on page 27 of the January issue of this journal. The general dimensions and ratios are as shown in the table at the end of this article.

The valve gear, as is always desirable, is practically all in one vertical plane, there being but $2\frac{1}{2}$ in. difference between the center of the pin on the eccentric crank and the valve stem; $1\frac{1}{2}$ in. of this is in an off-set in the eccentric rod and 1 in. is obtained at the connection of the radius bar to the combination lever. The valve chamber is thrown $\frac{3}{4}$ in. outside the center of the cylinders, which presents no objection other than the increase in the weight of the cylinder casting and slightly longer steam passage, provided the clearance limits are not exceeded.

The illustrations on the opposite page show the detailed design of the more important parts of the gear. The eccentric crank is of cast steel and fits over a $5\frac{5}{8}$ in. diameter extension of the main crank pin, to which it is secured by a $1\frac{1}{2}$ in. binding bolt. The crank is split at the back and a clearance of [illegible] in. allowed, so that it can be drawn tightly to a bearing by means of the bolt. The crank is maintained in its setting by a $\frac{3}{4}$ x 1 in. key and by the binding bolt fitting into a recess in the main pin, as is shown in the drawing. The pin on the end of the crank is $3\frac{1}{4}$ in. diameter, and is provided with a case hardened bushing shrunk into place, which forms a bearing for the eccentric rod brass. This method of fastening the crank to the main pin permits it to be removed if desirable by simply driving out the single binding bolt.

The eccentric rod is wrought iron and is fitted at the back end with a split brass bearing arranged with a wedge and adjusting screw for taking up wear. The forward end is in the form of a jaw for connection to the bottom of the link. This connection is made by a $1\frac{3}{4}$ in. pin, with taper fits in the rod and a counter sunk head on the inner side. The pin and the bushing in the link extension into which it fits are both case hardened. The link itself is made of hammered iron and case hardened, and is carried between two cast steel carriers, which have $3\frac{1}{4}$ in. trunnions fitted with case hardened bushings shrunk on and pinned to place. These trunnions rest in a cast steel bearing of special design, which fits between and is supported by two $1\frac{1}{2}$ x 6 in. rolled iron plates extending between the guide yoke and the extension of a special frame cross tie located between the first and second pair of drivers. These plates are set at $12\frac{3}{4}$ in. centers and form a very rigid support for all of the main members of the gear.



WALSCHAERT VALVE GEAR ON PACIFIC TYPE LOCOMOTIVE.

The reverse shaft is carried in bearings fastened between and to these plates at their connection to the frame cross tie. This bearing, which is shown in detail, is fitted with a cap held in place by two bolts, permitting the easy removal of the shaft. The reverse shaft arms are of cast steel in two parts, so constructed that the outer section of the arm can be removed without disturbing the shaft or inner arm. A block, having a sliding fit on

the square end of the radius bar, is fitted with trunnions which seat in the bearings of the reverse lever arm.

The radius bar itself is made in two parts, which are secured together just ahead of the link by three 1 in. bolts. This connection is specially designed, and details are shown in the illustration. The after section includes the sliding connection to the reverse shaft and the pin connecting to the link block. The details of this pin are also shown in the illustration.

The valve stem connects to the cast steel cross head, sliding upon a single bar guide, 2¼ x 3 in. in section, supported between the valve chamber head and guide yoke. The combination lever spans this cross head and its guide and is connected to it by a 1¾ in. pin, which is case hardened and runs in a case hardened bearing in the cross head. The union link is forked at both ends and is shown in detail in the illustration.

The provision for lubrication throughout the whole gear is exceptionally complete, as is also the provision for minimizing the wear at all bearing points. This has been done by the practically universal use of case hardened pins which fit in case hardened seats and run in case hardened bushings.

The general dimensions and other data of these locomotives are shown in the following table:

GENERAL DATA.	
Gauge	4 ft. 8½ in.
Service	Passenger
Fuel	Bitum. Coal
Tractive effort	26,000 lbs.
Weight in working order	196,000 lbs.
Weight on drivers	122,500 lbs.
Weight of engine and tender in working order	319,600 lbs.
Wheel base, driving	12 ft. 4 in.
Wheel base, total	32 ft. 7 in.
Wheel base, engine and tender	60 ft. 2 in.
RATIOS.	
Weight on drivers ÷ tractive effort	4.70
Total weight ÷ tractive effort	7.50
Tractive effort × diam. drivers ÷ heating surface	685.00
Total heating surface ÷ grate area	55.20
Firebox heating surface ÷ total heating surface, per cent	6.25
Weight on drivers ÷ total heating surface	47.80
Total weight ÷ total heating surface	76.10
Volume both cylinders, cu. ft.	9.50
Total heating surface ÷ vol. cylinders	270.00
Grate area ÷ vol. cylinders	4.90
CYLINDERS.	
Kind	Simple
Diameter and stroke	20 x 26 in.
VALVES.	
Kind	Piston
Greatest travel	6 in.
Outside lap	1⅛ in.
Inside clearance	1/16 in.
Lead, constant	3/16 in.
WHEELS.	
Driving, diameter over tires	68 in.
Driving, thickness of tires	3 in.
Driving journals, main, diameter and length	9 x 12 in.
Driving journals, others, diameter and length	8½ x 12 in.
Engine truck wheels, diameter	33 in.
Engine truck, journals	5½ x 10 in.
Trailing truck wheels, diameter	42 in.
Trailing truck, journals	8 x 14 in.
BOILER.	
Style	E. W. T.
Working pressure	200 lbs.
Outside diameter of first ring	62¼ in.
Firebox, length and width	96 x 70 in.
Firebox plates, thickness	⅜ & ½ in.
Firebox, water space	F-5, S & B-4½ in.
Tubes, number and outside diameter	250—2 in.
Tubes, length	18 ft. 6 in.
Heating surface, tubes	2,410.7 sq. ft.
Heating surface, firebox	160.4 sq. ft.
Heating surface, total	2,571.1 sq. ft.
Grate area	46.8 sq. ft.
Smokestack, diameter	16 in.
Smokestack, height above rail	14 ft. 3⅝ in.
TENDER.	
Tank	Water Bottom
Frame	13 in. channels
Wheels, diameter	33 in.
Journals, diameter and length	5½ x 10 in.
Water capacity	6,000 gals.
Coal capacity	10 tons

Greatest Lumber Cut.—The Forestry Service of the U. S. Department of Agriculture reports that more lumber was cut in the U. S. last year than in any other year in its history. A total of 37,550,736 board feet, which has a mill value of $621,151,388, was produced. In addition there were nearly 12,000,000,000 shingles, valued at $24,000,000, and nearly 4,000,000,000 laths, valued at $11,500,000. An investigation of circular No. 122, giving the different kinds of lumber produced, shows very clearly the passing of white pine and oak. Since 1899 the cut of the former has fallen off more than 40 per cent., and white oak has fallen off more than 36 per cent. Yellow pine leads all other woods in the amount cut, with Douglass fir as a second. Since 1899 the average increase in the price of lumber has been about 49 per cent.

HANDLING LOCOMOTIVE SUPPLIES.*

By E. Fish Ensie.

Part II.

Accounting.

Between reduced rates from adverse legislation, and the increased prices demanded for labor and material, railway managements are facing a condition which calls for a greater economy of operation per dollar earned, if the rapidly narrowing margin of profit is to be stayed and brought back even to the figures attained in the immediate past. If the return on the capital in railroad property is to approach a figure equivalent to the returns on investment in other commercial securities, a still greater effort must be made to use the facilities, equipment, and means for the carrying on of business, to the utmost limit of efficiency.

By reference to Moody's Manual for 1907, it will be found that of 674 "Independent" operating steam railroads in the United States, and of 57 large "Systems" (comprising 688 subsidiary companies), the former comprise not quite 11 per cent., and the latter nearly 90 per cent. of the railway mileage, thus showing to how great an extent consolidation and centralization of railway management has taken place in this country. We cannot hope, nor is it desirable, to return to the old conditions when the roads were so small that officer and man dealt personally with each other; for these personal relations of the past, now gone for ever, we must substitute an artificial means of keeping those in the saddle of responsibility in touch with the details of actual conditions, so that, having an intelligent view of the practices of the present, these responsible officers can lay down broader formulæ for the future.

Let us admit that the conditions of railroading have made operative costs so high that now the margin of net earnings is scarcely guaranteeing a proper return on capital investment (forcing one good sized road into receiver's hands); let us, however, remedy this condition, not by cutting off improvements under way, and necessary for economical operation of the future, but by looking to the efficiency and economy of organization and operation, with the view to reducing operative expense per unit of operation by the application of modern methods, and by the judicious stimulation of co-operative interest on the part of employees.

Let us look at our problem in this way: although we should no doubt continue to add to facilities and equipment, in order to prepare ourselves for the traffic of the future, when now we find capital for these additions hard to raise, hard to wring from dividends, we must use the equipment and facilities more efficiently and fully (a form of capitalizing earning capacity), and this applies whether we consider track in reference to its traffic carrying condition, or the investment in the supplies carried on locomotives.

The instrument, that combines the function of a telescope of inspection with a rifle of attack, for the modern officer of supervision, is a systematic method of accounting, designed to reflect actual detail operations. The basis for such an accounting system must be the prescribed Interstate Commerce Commission classification. If we are to have any intelligent supervision of locomotive supplies at all, we must have account of them properly and adequately rendered, and we must take as the basis of these accounts that portion of the Interstate Commerce Commission classification which relates to the articles comprising these supplies, and the costs of handling them.

These portions of the official classification are quoted verbatim in the following and those portions of special note in connection with this subject are italicized.

(The following, under the head of "Equipment," is taken from pages 23 and 24 of the "Classification of Expenditures for Road and Equipment, as Prescribed by the Interstate Commerce Commission, in Accordance with Section 20 of The Act to Regulate Commerce First Revised Edition"):

37. STEAM LOCOMOTIVES.—To this account should be charged the cost of steam locomotives and tenders, *including all appurtenances, furniture, and fixtures necessary to equip them for service,* purchased or built

* Continued from page 11 of the January, 1908, issue.

at the company's shops, including cost of transportation and setting up after receipt from builders.

38. ELECTRIC LOCOMOTIVES.—To this account should be charged the cost of electric locomotives, *including all appurtenances, furniture, and fixtures necessary to equip them for service*, purchased or built at the company's shops, including cost of transportation and setting up after receipt from builders.

(The following extracts are taken from the "Classification of Operating Expenses, as Prescribed by the Interstate Commerce Commission, in Accordance with Section 20 of The Act to Regulate Commerce, "Third Revised Issue"):

[*From Page* 18.]

Account.		Page.
II. MAINTENANCE OF EQUIPMENT—		
[29]	Steam Locomotives—Repairs	42

[*From Page* 19.]

IV. TRANSPORTATION EXPENSES—		
[78]	Enginehouse Expenses—Yard	68
[82]	Other Supplies for Yard Locomotives	69
[87]	Enginehouse Expenses—Road	71
[91]	Other Supplies for Road Locomotives	73

(Numbers in brackets refer to consecutive arrangement of Primary Accounts as listed on pages 17 to 20, inclusive, of the "Classification of Operating Expenses as Prescribed by the Interstate Commerce Commission in Accordance with Section 20 of The Act to Regulate Commerce—"Third Revised Issue—1907.")

[*From Pages* 42 *and* 43.]

STEAM LOCOMOTIVES—REPAIRS.

This account includes cost of material used (less salvage) and labor expended in repairing steam locomotives and tenders, and *fixtures thereof (except as otherwise provided for); such as air signal equipment, including hose, arm rests, awnings*, brake fixtures, *cab and steam-gage lamps, cab cushions, clocks, coal boards, fire extinguishers permanently attached to locomotives, gongs, head lamps*, pneumatic sanding equipment, *seat boxes, speed recorders*, steam and other power brakes, *steam-heat appliances, including hose and all other appliances of like nature, storm doors, tool boxes;* also cost of supervision; *pay of locomotive inspectors engaged in inspecting all parts of locomotives and tenders* (except pay of smokestack and ash-pan inspectors, which should be charged to account "Enginehouse Expenses—Yard" or "Enginehouse Expenses—Road"), pay of employees engaged in sponging tender, driving and truck boxes of locomotives undergoing repairs in shops (but pay of employees similarly engaged on locomotives not undergoing repairs in shops should be charged to account "Enginehouse Expenses—Yard" or "Enginehouse Expenses—Road"), and cost of cutting up condemned locomotives and tenders; small hand tools used exclusively in locomotive repairs; special service, such as bringing locomotives to shops or watching them while on the way to shops for repairs, and trying locomotives after having been repaired; traveling expenses of employees whose pay is chargeable to this account; and payments of royalties, or for patent rights on brakes, brake fixtures, and other appliances used on locomotives; also proportion of shop expenses as provided in Note following account "Other Expenses."

The value of old material released during repairs and insurance recovered should be credited to this account.

Note A.—The word "repairs" as here used *includes all repairs on or renewals of parts of locomotives and tenders commonly known as steam-locomotive fixtures or attachments*, and classified as running or roundhouse repairs; *also repairs to or renewals* of the more important or vital parts of locomotives and tenders, the necessity for which is *caused by breakage, failure, or accident while in service;* also the repairs to a steam locomotive or tender damaged through accident or otherwise, necessary to restore it to service: and also renewal of important or vital parts made necessary by reason of age or wear and tear from use.

Note B.—The cost of repairing steam locomotives and tenders of foreign lines waybilled as freight, damaged in transit, should be charged to account "Loss and Damage—Freight," and the cost of repairing steam locomotives of foreign lines having trackage rights over a carrier's line damaged in collision or wreck for which a carrier is liable should be charged to account "Damage to Property."

[*From Page* 68.]

ENGINEHOUSE EXPENSES—YARD.

This account includes *pay of, and cost of supplies furnished* to callers, watchmen. and other *employees* engaged in wiping, cleaning, firing up, *dumping, boiler washing*, cleaning fire boxes, watching, and dispatching locomotives; and of other enginehouse employees, such as *tool checkers*, enginehouse cleaners, *cinder pit cleaners*, clinker dumpers, truck packers, turntable operators, *sand dryers*, inspectors of smokestacks and ash pans, when engaged in caring for locomotives in yard or terminal service; also a proportion of wages paid enginehouse foremen and their clerks.

Some of the more important items chargeable to this account are: *Boiled oil, lampblack, rags, waste, lye, cleaning and polishing compounds, tools for truck packers and hostlers, signal lights on turntables and transfer tables at enginehouses*, expenses of operation of such tables by power; heating and lighting enginehouses and offices in them; oil for lubricating turntables; *shovels, wheelbarrows, and other tools for cleaning around enginehouses and handling cinders;* rent of cinder cars used at cinder pits; *hose* and water *for cinder pits and for washing out boilers*, cupboards in enginehouses, mechanical blowers and fire lighters for starting locomotive fires.

Note.—When enginehouse expenses are incurred jointly for yard and road locomotives they should be apportioned on basis of number of locomotives of each class handled.

[*From Page* 69.]

OTHER SUPPLIES FOR YARD LOCOMOTIVES.

This account includes the cost of *headlight and signal oil and wicks used in headlights, signal lights, and enginemen's torches; supplies for electric-light dynamos and carbide for acetylene gas for lights on locomotives in yard service;* also the *cost of furniture, tools, and other movable articles and supplies required fully to equip yard locomotives for service.*

[*From Page* 70.]

The following are some of the items chargeable to this account, when furnished for use of yard enginemen:

Ash hoes, Ash-pan rods, Axes, Bars, buggy, Bell cords, Boxes (portable), Brooms, Brushes, Buckets, Chimneys, headlights, Chisels, Clinker hooks, Crowbars, Files, Flags, Grate shakers, Hammers, Handsaws, Hatchets, Hose (not air brake, air signal, or steam), Hose reels, Jacks, Jackscrews, Lamps (signal only), Lanterns and parts, Locks for Portable boxes, Matches, Metallic packing, Oilers, Oil cans, Packing hooks, Packing spoons, Picks, Pinch bars, Plugging bars, Pokers, Saws, Scoops, Shovels, Slash bars, Sledges, Soap, Switch chains, Switch ropes, Switch poles, Thaw-out hose, Tool boxes (portable), Torches, Torpedoes, Water buckets, Water coolers, Wrecking frogs, Wrenches.

Note.—For cost of sand, see account "Other Supplies for Road Locomotives."

[*From Pages* 71 *and* 72.]

ENGINEHOUSE EXPENSES—ROAD.

This account includes *pay of and supplies furnished* to callers, watchmen, and other *employees* engaged in wiping, cleaning, firing up, *dumping, boiler washing*, cleaning fire boxes, watching, and dispatching locomotives; and of other enginehouse employees, such as *tool checkers*, enginehouse cleaners, *cinder pit cleaners*, clinker dumpers, truck packers, turntable operators, *sand dryers*, inspectors of smokestacks and ash pans, when engaged in caring for locomotives in road service; also a proportion of wages paid enginehouse foremen and their clerks.

Some of the more important items chargeable to this account are: *Boiled oil, lampblack, rags, waste, lye, cleaning and polishing compounds, tools for truck packers and hostlers, signal lights on turntables and transfer tables at enginehouses*, expense of operation of such tables by power, heating, and lighting enginehouses and offices in them, oil for lubricating turntables, *shovels, wheelbarrows, and other tools for cleaning around enginehouses and handling cinders;* rent of cinder cars used at cinder pits; *hose* and water *for cinder pits and for washing out boilers;* cupboards in enginehouses, mechanical blowers and fire lighters for starting locomotive fires.

Note A.—When enginehouse expenses are incurred jointly for yard and road locomotives, they should be apportioned on basis of number of locomotives handled.

Note B.—Cost of enginehouse expenses on locomotives engaged in work-train service should be charged as a part of work on which engaged.

[*From Page* 73.]

OTHER SUPPLIES FOR ROAD LOCOMOTIVES.

This account includes the cost of *headlight and signal oil and wicks used in headlights, signal lights, and enginemen's torches; supplies for electric light dynamos and carbide for acetylene gas for lights on locomotives in road service;* also the *cost of furniture, tools and other movable articles and supplies required fully to equip road locomotives for service; fuel for sand dryers and cost of sand and of loading it at sand pits; wheelbarrows, shovels, and sand screens used in handling sand for road locomotives.*

The following are some of the more important items chargeable to this account:

Ash hoes, Ash-pan rods, Axes, Bars, buggy, Bell cords, Boxes (portable), Brooms, Brushes, Buckets, Chimneys (headlight), Chisels, Clinker hooks, Crowbars, Files, Flags, Grate shakers, Hammers, Handsaws, Hatchets, Hose (not air brake, air signal, or steam), Hose reels, Jacks, Jackscrews, Lamps (signal only), Lanterns and parts, Locks for Portable boxes, Matches, Metallic packing, Oilers, Oil cans, Packing hooks, Packing spoons, Picks, Pinch bars, Plugging bars, Pokers, Sand, Saws, Scoops, Shovels, Slash bars, Sledges, Soap, Switch chains, Switch ropes, Switch poles, Thaw-out hose, Tool boxes (portable), Torches, Torpedoes, Water buckets, Water coolers, Wrecking frogs, Wrenches.

Note A.—Cost of other supplies for locomotives engaged in work-train service should be charged as a part of the work on which engaged.

Note B.—The cost of sand as between yard and road locomotives being undetermined, the entire cost of sand issued to all locomotives should be charged to this account.

The Interstate Commerce Commission prescribed accounts are the basis of our records—legally must be the basis. Those portions of them relating at all to locomotive supplies and equipments, and the handling of these supplies, etc., have been quoted in extenso, verbatim. For the purpose of seeing more clearly the items included in this mass of text, let us rearrange them in list form, and omit all text not strictly relevant to the supplies or their handling expense. There follows such an arrangement.

NEW LOCOMOTIVES—STEAM AND ELECTRIC.

Appurtenances, Furniture and Fixtures.

LOCOMOTIVE REPAIRS—STEAM AND ELECTRIC.

Material (less salvage); labor; fixtures; air signal equipment including hose; arm rests; awnings; cab and steam-gage lamps; cab cushions; clocks; coal boards; fire extinguishers permanently attached; gongs; head lamps; seat boxes; speed recorders; steam heat appliances including hose and appliances of like nature; storm doors; tool boxes; also supervision; locomotive inspectors; repairs on or removals of parts of locomotives and tenders, known as fixtures or attachments, caused by breakage, failure or accident.

ENGINEHOUSE EXPENSES—YARD AND ROAD.

Pay of and supplies furnished to employees; dumping; boiler washing; tool checkers and sand dryers; boiled oil; lampblack; rags; waste; lye; cleaning and polishing compounds; tools for truck packers and hostlers; signal lights on turntables; shovels; wheelbarrows; tools for cleaning around enginehouses and handling cinders; hose for cinder pits and for washing out boilers; cupboards in enginehouse.

OTHER SUPPLIES AND OIL FOR LOCOMOTIVES—YARD AND ROAD.

Headlight and signal oil and wicks; supplies for electric light dynamos carbide for acetylene gas; furniture; tools; movable articles and sup-

plies; fuel for sand dryers; sand and loading it; wheelbarrows; shovels; sand screens.

These are the items which the accounts must show. From what sources do we get the charges? The following will be a fairly complete analysis, although practice varies greatly on different roads:

Requisition for furniture for locomotives undergoing repair.
Requisition for material drawn to repair equipment.
Division Master Mechanic's Payroll, Repair Shop:
Time of inspectors, spent in inspecting locomotive equipment; cost of labor looking after and repairing equipment of engines in shops; time of clerks spent in drawing up special supervision accounts.
Requisition for locomotive supplies, yard.
Requisition for locomotive supplies, road.
Requisition for locomotive headlights and signals, yard.
Requisition for locomotive headlights and signals, road.
Ice drawn by enginemen.
Bills from foreign companies for supplies furnished at joint stations.
Material specially ordered, or specially made in shops, for test or experimental purposes.
Requisition for sand dryers' tools.
Fuel stock for sand dryers: Issued direct and directly charged on requisition, or apportioned on an arbitrary basis and when collected against the account for locomotive supplies, credited on account to which originally charged.
Bills and vouchers from contractors for sand furnished.
Division Superintendent's Payroll: Time of men engaged in loading and unloading sand for locomotive use, and in screening or working on it.
Time of sand dryers drying and unloading sand: (Time of hostlers or others putting sand on engines is not included here.)

APPROXIMATE APPORTIONMENT IN DETAIL OF VARIOUS EXPENSES CONNECTED WITH LOCOMOTIVE SUPPLIES AND EQUIPMENTS.

Item No.	Material.	I. C. C. accounts charged to	Approximate net charge under efficient and economical system per: Engine per month. At-tain-able min.	Engine per month. Max. al-low-able.	Engine per year. Min.	Engine per year. Max.	1,000 engines one year. Min.	1,000 engines one year. Max.	% of total cost.
100	Appurtenances, furniture and fixtures.	New locomotive equipment, steam and electric loco's.	$20 to $60, value of one complete equipment.		....	....	$20,000	$60,000	(60)
200	Renewals of fixtures, appliances, attachments.	Locomotive repairs. 29 steam loco's. 32 elec. loco's.	$0.15	$0.25	$1.50	$3.00	$1,500	$3,000	5
400	Headlight and signal oil.	Other supplies for locomotives. 82 yard loco's 91 road loco's	.80	2.00	10.00	25.00	10,000	25,000	27
500	Supplies, furniture, tools, movable articles.	Ditto.	.60	1.00	7.00	12,00	7,000	12,000	20
600	Fuel for sand dryers.	Ditto.	.05	.10	.50	1.00	500	1.000	2
700	Sand.	Ditto.	.05	.15	.50	1.50	500	1,500	2
800	Wheelbarrows, shovels and screens.	Ditto.	.05	.10	.50	1.00	500	1.000	2
300	Supplies, tools, cupboards for employes in engine houses	Enginehouse expenses. 78 yard 87 road	.40	1.00	5.00	15.00	5.000	15,000	13
900	Stationery and printing.	50 (M. of E.)	.01	.02	....	....	....	....	....
1000	Stationary and printing.	103 (C. T.)	.01	.03	....	.50	....	500	1
	Total material..................		$2.12	$4.65	$25.00	$59.00	$25,000	$59,000	72

Expense vouchers of supervisors of locomotive supplies and assistants.
Superintendent Motive Power Payroll: Supervisor of locomotive supplies and clerks. Time of draughtsmen on standard drawings.
Requisition for tools, supplies, apparatus and furniture used by enginehouse employees.
Division Master Mechanic's Payroll—Enginehouses: Time of firemen, inspectors, supply men, equippers, tool checkers, hostlers, and clerks spent directly on the inspection of, care of, and repair of, and accounting locomotive supply equipments.

The items of principal cost, and of principal interest to us, are those constituting the actual equipment carried on engines. That this is the case is evident from the following table, subdividing the various accounts (as built up from the several sources just listed) according to the *kind* of expenditure. The subdivision has been shown, also the numerical order of the accounts in the Interstate Commerce Commission classification, and a fair average of best practice proportions of expenses among the several accounts also shown on the basis of monthly and yearly costs per engine (with maximum and minimum limits in which good practice should find itself), on the basis of the total annual charges for these expenses to a road with 1,000 locomotives, and also each item as a per cent. of the total. Of course the latter figure is only a rough approximation.

APPROXIMATE APPORTIONMENT IN DETAIL OF VARIOUS EXPENSES CONNECTED WITH LOCOMOTIVE SUPPLIES AND EQUIPMENTS.

Item No.	Labor.	I. C. C. accounts charged to	Approximate net charge under efficient and economical system per: Engine per month. At-tain-able min.	Engine per month. Max. al-low-able.	Engine per year. Min.	Engine per year. Max.	1,000 engines one year. Min.	1,000 engines one year. Max.	% of total cost.
202	Labor.	29 32	.05	.10	.50	1.00	$500	1,000	2
220	Supervision.	29 32	.05	.15	.50	2.00	500	2,000	2
222	Loco. inspectors.	29 32	.05	.10	.50	1.00	500	1,000	2
1050	Superintendence and expenses.	66 (C. T.)	.10	.20	1.00	2.50	1,000	2,500	3
305	Pay of employes and tool checkers.	78 87	.40	.60	5.00	7.00	5,000	7,000	12
308	Sand dryers.	78 87	.08	.20	1.00	2.50	1,000	2.500	2
303	Truck packers and hostlers.	78 87	.15	.25	1.50	2.50	1,500	2,500	5
	Total labor....................		.88	1.60	10.00	18.50	10,000	18,500	28
	Grand total..........................		$3.00	6.25	35.00	77.50	35,000	77,500	100
	Average......		3.50	5.00	40.00	60.00	40,000	60,000	......
	Other sup'lies for locomotives excluding oil.	82 91	.60	1.00	7.00	12.00	7,000	12.000	20
	Headlight and signal oil.	Ditto.	.80	2.00	10.00	25.00	10,000	25,000	27
	Total above.	Ditto.	1.40	3.00	17.00	37.00	17,000	37,000	47
	Total of account (items of 400, 500, 600, 700, 800)	Ditto.	1.55	3.35	18.50	40.50	18,500	40,500	53
	Locomotive supplies only including labor and supervision directly connected therewith (items 200, 500, 900, 1000, 202, 220, 222, 1050, 305).		1.42	2.45	16.00	29.00	16,000	29,000	47
	And excluding oil, sand and engine-house expenses not directly concerned with supplies carried on locomotives (i. e., excluding items 300, 400, 600, 700, 800, 308, 303).		3.00	6.25	35.00	77.50	35,000	77.500	53

(Check) 1st to 10th, 11th to 20th, 21st to 30th Month / Day	of Month	Service	Running to	Loco. number	Engineer initials	Engineer page no.	Fireman initials	Article	Quantity New	Quantity Old	Account Charges loco-r'p'rs st'm 29	loco-r'p'rs el'c. 32	loco-supl's y'd 82	loco-supl's r'd 91	oil y'd 82	oil r'd 91	total		(Check) Month or date
J this mo. total 1																			J 1
F 2																		Article Dw'g no. Cost	F 2
M 3																		Index symbol Size	M 3
A 4																			A 4
M 5																		Store Run'g to Service	M 5
BLANK RAILWAY J 6																		Div'n Loco. no.	J 6
J 7																		Page no.	J 7
A 8																		Initials Initials	A 8
S 9																		from	S 9
O 0																		drawn name: name:	O 0
N 31																		Supplies Engineer's Fireman's	N 31
D total																			D
																		Page number 0000	

ORIGINAL REQUISITION BLANK.

As we are most interested in the history of the engine equipment and supplies proper, it will be well to give detail forms for use in handling this phase of the matter. Two basic forms are submitted, one an original requisition blank, and the other a general summary sheet. The requisition here shown is not meant altogether to be adopted as it stands in toto for practical use, but it is meant to give almost all the data required for complete supervision purposes. Actually, no doubt, several items of information shown might be omitted without detracting from the efficiency of the general accounting scheme.

The other form, that showing summaries and recapitulations, had its origin in the brain of one of our best railroad general storekeepers. He is not responsible for the present form of the record, but the general principle of a daily distribution sheet, giving a line to each day, and columns for the several accounts and subdivisions of accounts, is his, and it has worked out most excellently in looking after over $30,000,000 worth of material issues per year. The adaptation of the loose leaf principle to this record is also due to his suggestion.

The forms are 5 x 8 in. in size; are printed in light brown ink so as to leave the written record more conspicuous than the printing; are printed on cheap manila paper and furnished in pads of 150 gummed together on the binding edge; are punched for loose leaf use; are ruled (either color rulings or printed rulings may be used; if color is used the shade of all lines is light blue except those separating dollars and cents which should be in red) in multiples of 1/6th inch (horizontal rulings) and 1/10th inch (vertical), which accords with standard typewriter spacing.

Complete instructions (a suggestion for which is reproduced herewith) are printed on the back of each form, both to insure accuracy in making out the reports, and to prevent the use of the form for scratch pad purposes. The clearance, for old equipment returned, or not returned, will be illustrated in a subse-

Item	Quantity New	Quantity Old	Article	Price mat'l	lab'r	s'ch'g	fr't & exp.	price	Account Chargeable loco-r'p'rs st'm 29	loco-r'p'rs et'c 32	eng. h'se y'd 78	eng. h'se r'd 87	loco-supl. y'd 82	loco-supl. r'd 91	oil y'd 82	oil r'd 91	other	credit	total	Clearance Check — Requisition Number 0000
1																				
2																				
3																				
4																				
5																				
6																				
BLANK RAILWAY 1	Below to be filled out by items, only when delivery of any item is not made on date and place requisition presented										req'n	req'	by			Store	on wh.	req'n	made	
2											req'n	made	by			Store	fil	ling	req'n	
3											req'n	sign'd supply-man	by			Hon			sent	
4											E-h's	or G'l	F'r'm			Div'n	S'r'c	Loco. no	Run'g to	
5											Div.	M'r	M'n			Engi	neer	Fire	man	
6											req'n store	r'c'd att-nd't	by							
	DATE	req'n filled	By	(Initials)	Date shipped	By	(Initials)	invoiced to	(Initials)	Date rec'd	By	(Initials)	Date used	By	(Initials)	Dates				Store Number

GENERAL SUMMARY SHEET.

quent issue. The printing looks somewhat crowded, but this is no serious drawback, owing to the use of the brown ink, so that one may write a legible record over the printed matter without destroying the value either of the form of the record information.

INSTRUCTIONS FOR MAKING OUT REQUISITIONS.

No item of supplies, tools, equipment, fixtures, appliances, furniture, appurtenances, attachments, movable articles and the like, for use on locomotives, may be issued to any engine, engineman, supplyman, equipper, inspector, foreman, mechanic, tool checker, or other person, and charged to a locomotive, or to one of the accounts designated on the opposite side of this form, unless such item is properly requisitioned on this form in triplicate, and signed by the supplyman or person authorized in his place to sign requisition for such material.

Requisition blanks will be furnished periodically as they are used up by those persons authorized to issue them. Take up all correspondence as to requisition with supervisor of locomotive supplies.

Nor will any requisition be honored unless it bears the information required in columns or spaces as follows:

Quantity (indicating what article is new or old).
Article (with correct symbol or unequivocal name).
Correct charge to correct account.
Initials of supplyman or issuer of requisition.
Store on which requisition is made.
Engine number.
Running to.
Engineer's initials (according to authorized list of initials).
Firemen's initials (according to authorized list of initials).

If the article requires a clearance for the old one before a new one is issued, requisition must be accompanied by clearance properly filled out in triplicate.

For instructions as to filling out clearance see back of clearance form (Form 000 Standard).

If clearance is turned in, check in "Clearance Check" column with letter C. If no clearance is turned in, check with letter N. If old article is returned, check with letter O. If no old article is returned, check with X.

Other information should be filled in as far as known and as circumstances require.

Originals of requisitions will be retained by storekeeper honoring same as his authority for the issue of material.

First duplicate will be forwarded promptly on date of issue by storekeeper to office of supervisor of locomotive supplies.

Second duplicate will be retained by supplyman or equivalent person for his permanent file, in the binder provided for the purpose, where it may be referred to at any time. File requisitions numerically.

No requisition blanks shall be destroyed, or used for other purpose; blanks spoiled in any way before use are to be sent with other requisitions to office of supervisor of locomotive supplies.

INSTRUCTIONS FOR FILLING OUT SUPPLY ACCOUNT FORM.

This form is designed to be used for a number of different purposes, so as to reflect to the supervisor of locomotive supplies, various aspects of the detailed information shown on the supply requisition form.

This form will summarize and consolidate the information shown on the requisitions by engines, for purposes of account and distribution; by engineers, for the purpose of fixing responsibility; by firemen for a similar purpose with reference to tools and supplies used by and drawn for them; and by articles, so as to indicate those classes of articles which are occasioning the bulk of the expense, with a view to remedying defects in them in case high expense is caused by defects.

The form is arranged for drawing off the information from the requisitions article by article as drawn, or for issues to engines or enginemen, or by articles for each day, or for each month, or for each year. It will be noted that the lines permit of an entry being made for 10 days, thus requiring three sheets for one month's record; also one line is provided for each month, and provision is made so that the total of given number of months (those since the beginning of the last fiscal or calendar year, for instance, the preceding 11 months added to the month in question, thus giving a yearly total for the 12 months, ending each month; or what is more convenient and practically as good, the preceding 9 months taken together with the current month, making 10 months in all, and thus making apparent at a glance what the average issues per month for a long recent period are).

The plan of having 10 days on a sheet permits of closer touch being kept with these costs than is the case with records that run for a whole month before they are closed, and abuses may be corrected at their inception.

Not only does this form provide individual records variously arranged, and for short and long periods of time, but it may be conveniently used for summarizing or recapitulating the various individual records of engines, enginemen, and articles.

Furthermore, individual items, daily and monthly records of each class, may be also recapitulated for each station where stores are issued, for each operative division, and for groups of divisions.

Particular instructions follow relative to the manner of using this information for each class of record.

RECORD BY ENGINES.

The articles as drawn on requisition will be entered up in detail for all the articles on the requisition. The day of the month will be written in in the first left-hand marginal column provided for that purpose. Entries will be made in all the succeeding columns except that provided for the engine number (which is entered for this sheet in the space provided on the righ-hand margin), engineer's page number, and total account charges.

Referring now to the right-hand margin the following entries only will be made: Supplies drawn from................. store, division, engine number, "running to" and "service" if permanent assignment.

These individual entries can now be summarized according to any of the desired arrangements without having again to refer to copies of the original requisition form. A daily distribution of the charges on each account, to each engine may be had, omitting reference to specific articles, enginemen or trips. Similarly a monthly distribution may be had.

The engines for a given day, or for all the days of a month, or as a total for a month, may be conveniently summarized on this sheet, showing the total charges to each, for the period desired, on each account and the total for all accounts. In the case of such a summary, all entries would be ignored except the following:

In columns.
Engine number.
Account charges.
In right margin.
Supplies drawn from................ store.
Division.

Without further going into detail in respect to the entries for individuals, and groups, of enginemen, and of articles, it will be readily seen that almost any desired arrangement of entry can be made with this form in order to reflect the actual information desired for supervision purposes.

As an example of what the individual engine record will show, an instance is given of charges to six engines for supplies and equipments furnished during one single month. These engines were received new from the locomotive works, and had to travel over about 1,000 miles of foreign rail lines and about 400 miles of home lines before they reached the central shop where they were to be set up and made ready for service. It was found, by the time they were ready to "break in" that most of the equipment which had been ordered with them from the builders, and which had been placed on them at the locomotive works, was altogether missing, and nearly complete new equipment had to be provided.

The engines were then sent to the division on which they were to operate, another 800 miles away. After undergoing another "setting up," this was the cost of the equipment that was supplied to each engine:

Engine.	Charges.
6	$67.28
7	81.22
8	93.59
9	101.65
10	87.32
5	97.85
Total for six new engines	$528.35
Average	88.07

The average cost is in excess of the total cost for a complete equipment, as per standard equipment form; this form, however, included many items that were never applied in practice to the engine. The total value of equipment according to the form was about $84.00; the value of the supplies, etc., actually put on when the engines were fully equipped for road service was in the neighborhood of $70.00. It will be seen that one of the engines in this list exceeded the cost of a total equipment by nearly 40 per cent.

With these figures at hand, the attention of all concerned was so forcibly drawn to the shockingly wasteful cost that when the next lot of engines came over the same route, the charges were reasonable. This is an illustration of what proper accounting will reveal to him who wishes to supervise efficiently.

Not more than $2.00 worth of supplies need to be drawn on an average, per month, per engine. In one month, the issues classified according to value, were as follows on three divisions of a certain road:

NUMBER OF ENGINES DRAWING EQUIPMENT.

Division	under $1.00	under $2.00	under $3.00	under $4 00	Over $4.00	Highest Amount Drawn for one Engine
A	24	23	12	10	37	$75.46
B	34	17	14	8	24	20.48
C	30	16	12	7	20	19.62

It is evident that over one-half the engines do get along drawing an average of less than $2.00 per month.

If we take a period of several months for a division, this is still more evident.

PERIOD COVERED—SEVEN MONTHS.

	About $1.00	Under $2.00	Under $4.00	Under $5.00	Over $5.00
Engines	$ .09	$ .14	$ .20	$ .06	$ .07
Total Amount	69.09	163.18	417.95	181.60	427.01
Average per engine	7.12	11.66	20.89	30.77	61.11
Average per engine per month	1.02	1.67	2.99	4.32	8.73

Highest for one engine—period seven months.. $94.17
Average per month for that engine........... $13.45

To only 12 per cent. of the engines 35 per cent. of the issues go, or to one-quarter of the engines, half. Yet over half the engines, through this whole period, get along with an average of less than $2.00 issues per month.

It would naturally seem as if the lowest records made by engineers for small tools and supplies will be most rapidly acquired on small engines in branch service.

But after having gone very carefully into the matter, and using

as a basis of comparison the ratio of engineers' wages to cost of supplies issued, the mileage or the service of the engine being proportional to these wages, it becomes evident that the larger and main line engines actually seem to cost less. Taking one month on one particular division we find that for every dollar in wages paid to the engineer, the amount of supplies drawn, averaged over all engines in each class of service, is as follows:

Large main line engines	$0.0200
Small main line engines	.0462
Small branch line engines	.0759
Engines in switch service	.0201

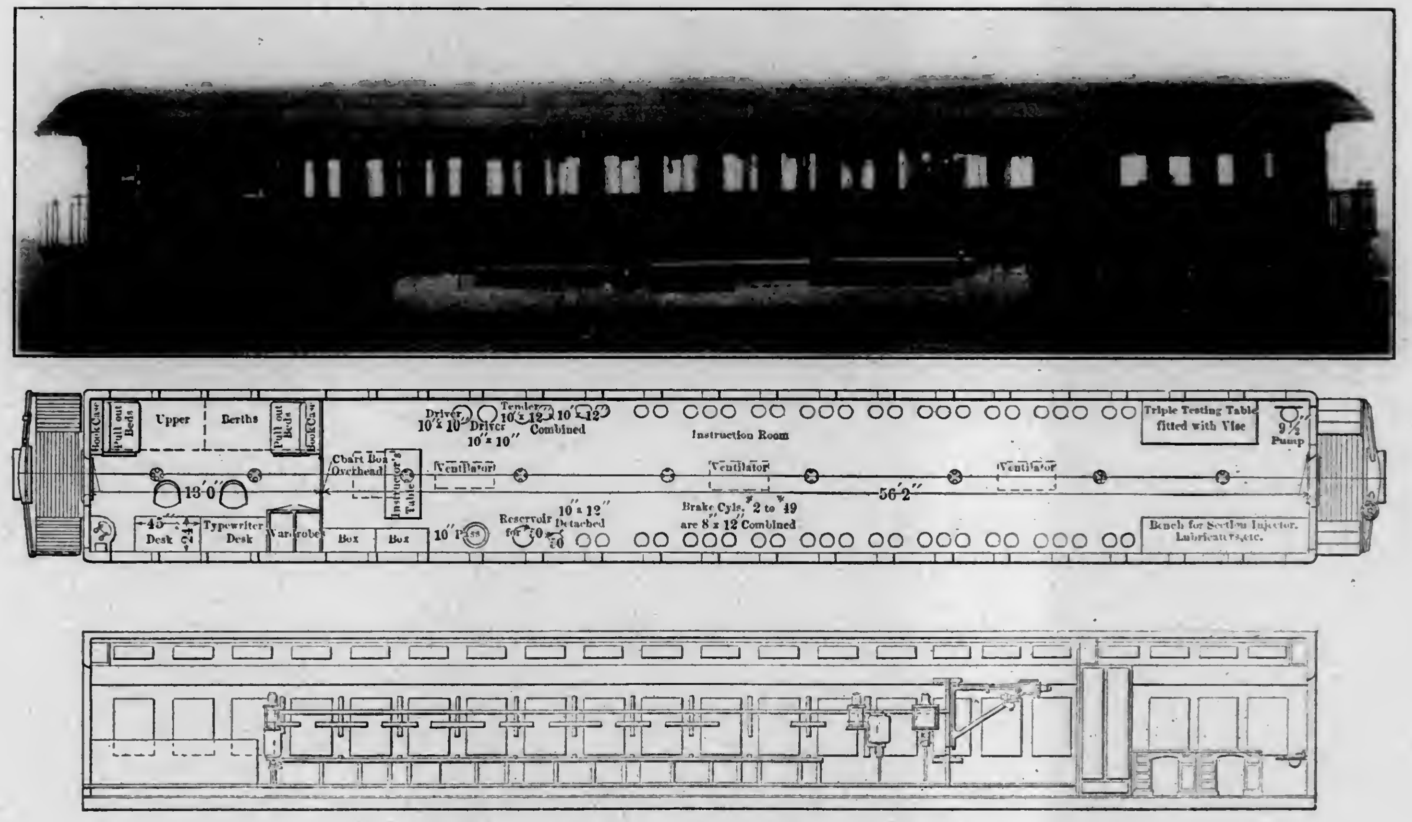
The "Primary Transportation Accounts" known as "Other Supplies for Locomotives" in yard and road service, are insignificant in gross amounts, compared with most other subdivisions of operating expense; they actually run from ¼ of one per cent. to less than one per cent. of the total conducting transportation expense, and it may seem that undue prominence is being given in this article to the petty details of a trifling and unimportant matter. Yet it must be remembered that it is often a serious matter for a locomotive to run improperly equipped, that if first attention is given to efficiency in this matter, economies are sure to result, and that such economies will amount to thousands and in some cases even hundreds of thousands of dollars per year; the improvement and the savings of revenue for net earnings are both worth the effort involved in securing them; and it should be noted that the analytical method nere outlined, upon which the constructive work of intelligible and correct accounting and economical efficient supervision is built, is applicable to many large fields of railway operation. Readers should keep this *method* in view when perusing this article, as a principle of much greater value than even the profitable proposition of handling locomotive supplies.

RECORD OF LOCOMOTIVE EQUIPMENT COSTS OF A ROAD OWNING ABOUT 1,100 LOCOMOTIVES, SHOWING REDUCTIONS EFFECTED. THIS ACCOUNT WAS TOTALING ABOUT $80,000 PER YEAR, AND WAS ON THE INCREASE, WHEN TAKEN HOLD OF

	Issues to Locomotives.		Pay of tool checkers second year.
	First year.	Second year.	
January	....	$1183	$1056
February	....	1509	911
March	....	1612	918
April	....	1581	887
May	$4916	1504	978
June	4996	1673	845
July	4132	1110	....
August	1519	....	....
September	1395	....	....
October	1469	....	....
November	1392	....	....
December	1182	....	....

NOTE OF ERRATUM.

On page 8 of the preceding instalment of this article appeared two diagrams giving the cost of locomotive supplies in American railway practice in tenths of a cent "per revenue ton mile;" the legends (and also line 2, from the bottom, second column, of the same page) should have read, in tenths of a cent "per 100 revenue ton miles."



AIR BRAKE INSTRUCTION CAR—CENTRAL RAILROAD OF NEW JERSEY.

AIR BRAKE INSTRUCTION CAR.

CENTRAL RAILROAD OF NEW JERSEY.

The Central Railroad of New Jersey has just completed at its Elizabethport shops a very completely equipped and excellently arranged air brake instruction car. This car was designed in the mechanical engineer's office and consists of a wooden passenger car body, 70 ft. over end sills, in which is included complete air brake equipment for a 50-car freight train, a 5-car passenger train with locomotive and tender, as well as other separate and special brake, lubricator and injector parts.

The car is divided into two compartments, one 13 ft. long, equipped as an office and containing two desks, book-cases, berths, clothescloset, wash-basin, etc., and the instruction room, which is 52 ft. long. The 50-freight-brake cylinders are hung from iron racks along each side of the car, in the instruction room, and each is provided with a double bracket with three-way valve for the attachment of the "K" and "H" triple valve, either of which may be cut into service or both cut out entirely. The triples set in a horizontal position the same as in regular service. Gages with large dials are connected at different points and can be read from the end of the compartment. A full length of standard sized pipe accompanies each brake cylinder and is arranged in sections resting on the regular car flooring. A false flooring, secured to sub sills, covers this piping. Any portion of this false floor can readily be removed for inspection and by the use of cut-out cocks it is possible to cut the brake cylinders into groups and give the

quent issue. The printing looks somewhat crowded, but this is no serious drawback, owing to the use of the brown ink, so that one may write a legible record over the printed matter without destroying the value either of the form of the record information.

INSTRUCTIONS FOR MAKING OUT REQUISITIONS.

[illegible] equipment, fixtures, appliances, furniture, [illegible] and the like, for use on locomotives, may be issued to any engine, engineman, supplyman, equipper, [illegible] checker, or other person, and charged to [illegible] one of the accounts designated on the opposite side of this form [illegible] properly [illegible] on this form in triplicate, [illegible] or person authorized in his place to sign requisition for such material.

Requests for blanks will be furnished periodically as they are used up by [illegible] to issue them. Take up all correspondence as to [illegible] with supervisor of locomotive supplies.

No [illegible] requisition [illegible] unless it bears the information required in columns or spaces as follows:

Quantity (indicating what article is new or old).
Article (with correct symbol or unequivocal name).
Correct charge to correct account.
Initials of supplyman or issuer of requisition.
Store on which requisition is made.
Engine number.
Running [illegible].
Engineer's initials (according to authorized list of initials).
Fireman's initials (according to authorized list of initials).

If the article requires a clearance for the old one before a new one is issued, requisition must be accompanied by clearance properly filled out in triplicate.

For instructions as to filling out clearance see back of clearance form (Form [illegible] Standard).

If clearance is turned in, check in "Clearance Check" column with letter C. If no clearance is turned in, check with letter N. If old article is returned, check with letter O. If no old article is returned, check with N.

Other information should be added in as far as known and as circumstances require.

Originals of requisitions will be retained by storekeeper honoring same as his authority for the issue of material.

First duplicate will be forwarded promptly on date of issue by storekeeper to office of supervisor of locomotive supplies.

Second duplicate will be retained by supplyman or equivalent person for his permanent file in the binder provided for the purpose, where it may be referred to at any time. File requisitions numerically.

No requisition blanks shall be destroyed, or used for other purpose, blanks spoiled in any way before use are to be sent with other requisitions to office of supervisor of locomotive supplies.

INSTRUCTIONS FOR FILLING OUT SUPPLY ACCOUNT FORM.

This form is designed to be used for a number of different purposes, so as to reflect to the supervisor of locomotive supplies various aspects of the details of information shown on the supply requisition form.

This form will summarize and consolidate the information shown on the requisitions by engines, for purposes of account and distribution; by engineers, for the purpose of fixing responsibility; by firemen for a similar purpose with reference to tools and supplies used by and drawn for them; and by articles, so as to indicate those classes of articles which are occasioning the bulk of the expense, with a view to remedying defects in them [illegible] high expense is caused by defects.

The form is arranged for drawing off the information from the requisitions article by article as drawn, or for issues to engines or enginemen, or by articles for each day, or for each month, or for each year. It will be noted that the lines permit of an entry being made for 10 days, thus requiring three sheets for one month's record; also one line is provided for each month, and provision is made so that the total of given number of months (those since the beginning of the last fiscal or calendar year, for instance, the preceding 11 months added to the month in question, thus giving a yearly total for the 12 months, ending each month; or what is more convenient and practically as good, the preceding 9 months taken together with the current month, making 10 months in all, and thus making apparent at a glance what the average issues per month for a long recent period are.

The plan of having 10 days on a sheet permits of closer touch being kept on these costs than is the case with records that run for a whole month, and [illegible] may be corrected at their inception.

[illegible] records variously arranged, [illegible] but it may be conveniently used [illegible] records of engines, [illegible].

[illegible] records of each class [illegible] stores for issuing, for [illegible].

[illegible] using this [illegible].

[illegible]

[illegible] detail [illegible] month will be written [illegible] for this purpose. Entries [illegible] provided for the [illegible] space provided on [illegible] total account charges.

[illegible] will [illegible] store, division, engine [illegible] assignment.

[illegible] according to any of the [illegible] the original requisition [illegible] the charges on each account, or [illegible] to specific articles, enginemen [illegible] may be had.

The [illegible] for all the days of a month, [illegible] summarized on this sheet, showing the [illegible] desired, on each account and the [illegible] summary, all entries would be [illegible]:

[illegible]
[illegible]
[illegible]
[illegible] store
[illegible]

Without [illegible] detail in respect to the entries for individuals, [illegible] of articles, it will be readily seen that almost any desired arrangement of entry can be made with this form in order to reflect the actual information desired for supervision purposes.

As an example of what the individual engine record will show, an instance is given of charges to six engines for supplies and equipments furnished during one single month. These engines were received new from the locomotive works, and had to travel over about 1,000 miles of foreign rail lines and about 400 miles of home lines before they reached the central shop where they were to be set up and made ready for service. It was found, by the time they were ready to "break in" that most of the equipment which had been ordered with them from the builders, and which had been placed on them at the locomotive works, was altogether missing, and nearly complete new equipment had to be provided.

The engines were then sent to the division on which they were to operate, another 800 miles away. After undergoing another "setting up," this was the cost of the equipment that was supplied to each engine:

Engine.	Charges.
6	$67.28
7	81.22
8	93.59
9	101.65
10	87.32
5	97.85
Total for six new engines	$528.85
Average	88.07

The average cost is in excess of the total cost for a complete equipment, as per standard equipment form; this form, however, included many items that were never applied in practice to the engine. The total value of equipment according to the form was about $84.00; the value of the supplies, etc., actually put on when the engines were fully equipped for road service was in the neighborhood of $70.00. It will be seen that one of the engines in this list exceeded the cost of a total equipment by nearly 40 per cent.

With these figures at hand, the attention of all concerned was so forcibly drawn to the shockingly wasteful cost that when the next lot of engines came over the same route, the charges were reasonable. This is an illustration of what proper accounting will reveal to him who wishes to supervise efficiently.

Not more than $2.00 worth of supplies need to be drawn on an average, per month, per engine. In one month, the issues classified according to value, were as follows on three divisions of a certain road:

NUMBER OF ENGINES DRAWING EQUIPMENT.

Division	under $1.00	under $2.00	under $3.00	under $4.00	Over $4.00	Highest Amount Drawn for one Engine
A	24	23	12	10	37	$78.16
B	34	17	11	8	24	20.48
C	0	1	12	7	20	19.62

It is evident that over one half the engines do get along drawing an average of less than $2.00 per month.

If we take a period of several months for a division, this is still more evident.

PERIOD COVERED—SEVEN MONTHS.

	About $1.00	Under $2.00	Under $4.00	Under $[illegible]	Over $5.00
Engines	[illegible]	14	[illegible]	[illegible]	[illegible]
Total Amount	[illegible]	[illegible]	[illegible]	[illegible]	127.01
Average per engine	[illegible]	11.66	[illegible]	30.77	61.11
Average per engine per month	[illegible]	[illegible]	[illegible]	4.39	8.73

Highest for one engine—period seven months... $94.17
Average per month for that engine............ $13.45

To only 12 per cent. of the engines 35 per cent. of the issues go, or to one-quarter of the engines, half. Yet over half the engines, through this whole period, get along with an average of less than $2.00 issues per month.

It would naturally seem as if the lowest records made by engineers for small tools and supplies will be most rapidly acquired on small engines in branch service.

But after having gone very carefully into the matter, and using

as a basis of comparison the ratio of engineers' wages to cost of supplies issued, the mileage or the service of the engine being proportional to these wages, it becomes evident that the larger and main line engines actually seem to cost less. Taking one month on one particular division we find that for every dollar in wages paid to the engineer, the amount of supplies drawn, averaged over all engines in each class of service, is as follows:

Large main line engines	\$0.0260
Small main line engines	.03[illegible]2
Small branch line engines	.0[illegible]0
Engines in switch service	.0281

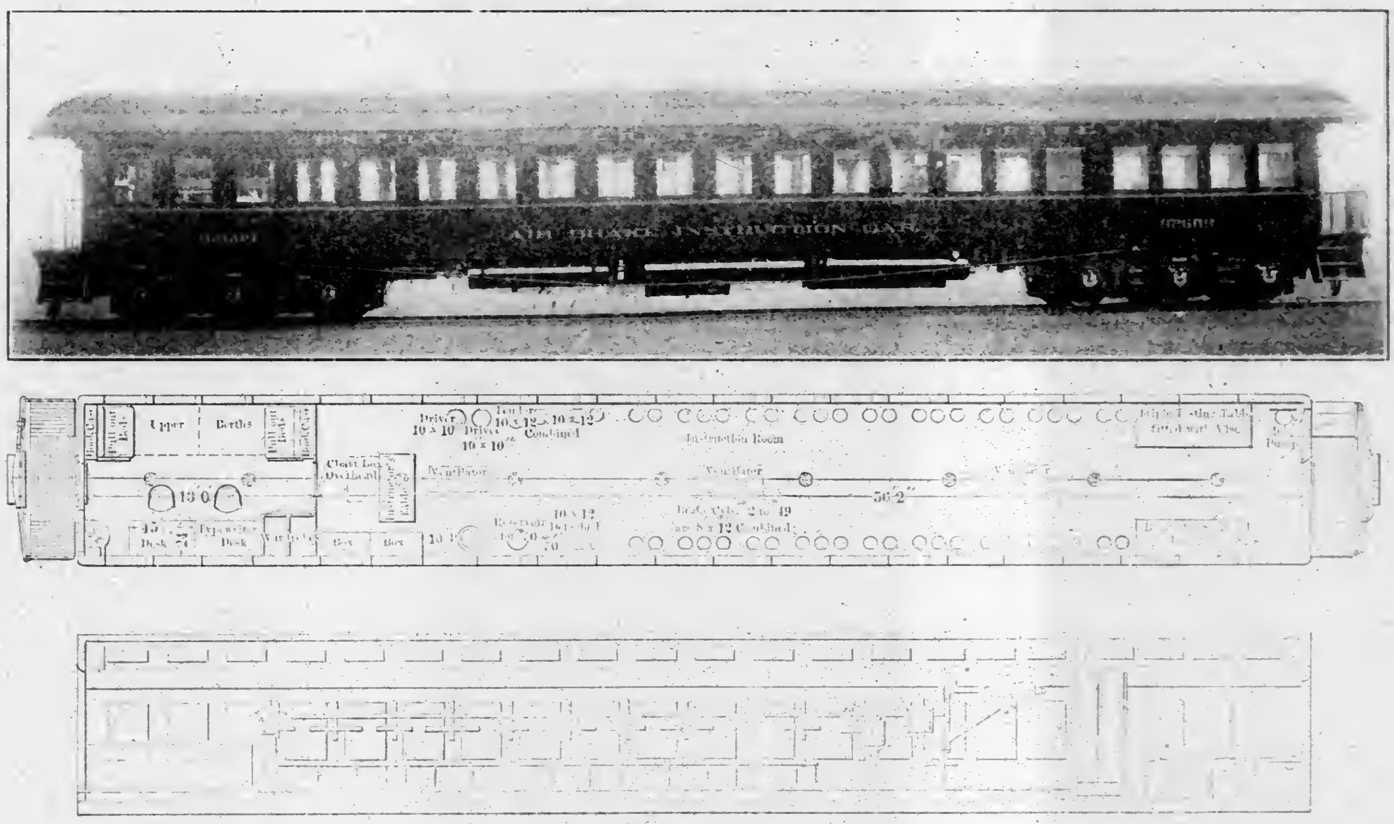
The "Primary Transportation Accounts" known as "Other Supplies for Locomotives" in yard and road service, are insignificant in gross amounts, compared with most other subdivisions of operating expense: they actually run from ¼ of one per cent. to less than one per cent. of the total conducting transportation expense, and it may seem that undue prominence is being given in this article to the petty details of a trifling and unimportant matter. Yet it must be remembered that it is often a serious matter for a locomotive to run improperly equipped, that if first attention is given to efficiency in this matter, economies are sure to result, and that such economies will amount to thousands and in some cases even hundreds of thousands of dollars per year; the improvement and the savings of revenue for net earnings are both worth the effort involved in securing them; and it should be noted that the analytical method here outlined, upon which the constructive work of intelligible and correct accounting and economical efficient supervision is built, is applicable to many large fields of railway operation. Readers should keep this *method* in view when perusing this article, as a principle of much greater value than even the profitable proposition of handling locomotive supplies.

RECORD OF LOCOMOTIVE EQUIPMENT COSTS OF A ROAD OWNING ABOUT 1,[illegible] LOCOMOTIVES, SHOWING REDUCTIONS EFFECTED. THIS ACCOUNT WAS TOTALING ABOUT \$[illegible] PER YEAR AND WAS ON THE INCREASE WHEN TAKEN HOLD OF.

	Issues to Locomotives. First year.	Issues to Locomotives. Second year.	Pay-off [illegible] check [illegible]
January		[illegible]	[illegible]
February		150[illegible]	[illegible]
March		[illegible]	[illegible]
April		158[illegible]	[illegible]
May	\$1916	15[illegible]4	[illegible]
June	[illegible]	16[illegible]	[illegible]
July	4132	[illegible]	
August	1514		
September	1395		
October	1150		
November	1302		
December	1182		

NOTE OF ERRATUM.

"On page [illegible] of the preceding installment [illegible] grams giving the cost of [illegible] supplies in [illegible] in tenths of a cent "per revenue ton mile." The legends [illegible] the bottom, second column, [illegible] same page [illegible] tenths of a cent "per [illegible] revenue ton miles."



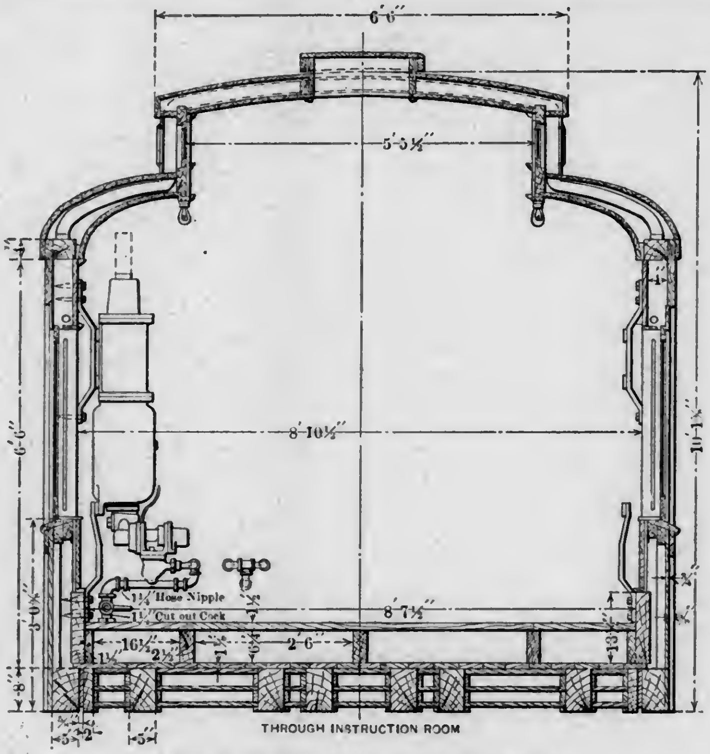
AIR BRAKE INSTRUCTION CAR—CENTRAL RAILROAD OF NEW JERSEY.

AIR BRAKE INSTRUCTION CAR.

Central Railroad of New Jersey.

The Central Railroad of New Jersey has just completed at its Elizabethport shops a very completely equipped and excellently arranged air brake instruction car. This car was designed in the mechanical engineer's office and consists of a wooden passenger car body, 70 ft. over end sills, in which is included complete air brake equipment for a 50-car freight train, a 5-car passenger train with locomotive and tender, as well as other separate and special brake, lubricator and injector parts.

The car is divided into two compartments, one 13 ft. long, equipped as an office and containing two desks, book-cases, berths, clothes-closet, wash-basin, etc., and the instruction room, which is 52 ft. long. The 50-freight brake cylinders are hung from iron racks along each side of the car in the instruction room, and each is provided with a double bracket with three-way valve for the attachment of the "K" and "H" triple valve, either of which may be cut into service or both cut out entirely. The triples set in a horizontal position the same as in regular service. Gages with large dials are connected at different points and can be read from the end of the compartment. A full length of standard sized pipe accompanies each brake cylinder and is arranged in sections resting on the regular car flooring. A false flooring, secured to sub sills, covers this piping. Any portion of this false floor can readily be removed for inspection and by the use of cut out cocks it is possible to cut the brake cylinders into groups and give the



SECTION OF AIR BRAKE INSTRUCTION CAR.

proper number of brakes for a 5, 10, 20, 30, 40, 45 and 50-car train.

The illustration shows the arrangement of the apparatus and its piping. The 5-car passenger train is obtained by equipping five of the freight cylinders with a high speed reducing valve which can be cut in if desired. The 10-in. passenger brake cylinder, which has a slack adjuster and a P1 triple in tandem, is mounted upon a crane and can be swung out in front of the instructor's table. On the opposite side of the car is another crane supporting two 10-in. brake cylinders with K and L triples and sectional triples arranged in tandem. The air signal instruction apparatus consists of a 12-car train equipment, and is located under the lower deck on each side.

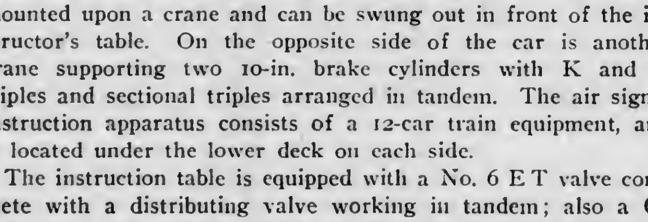
The instruction table is equipped with a No. 6 E T valve complete with a distributing valve working in tandem; also a G6 engineer's valve, which can be used with or without straight air.

All of this apparatus can be arranged for high speed brakes. The 9½-in. air pump provided can be operated by steam or air, either direct or compound, thus being able to furnish any desired air pressure. This pump is operated by steam or air connections from pipe lines at the various shops or stations, no boiler being provided in the car. The auxiliaries for the driver, tender and passenger cylinders are located under the car.

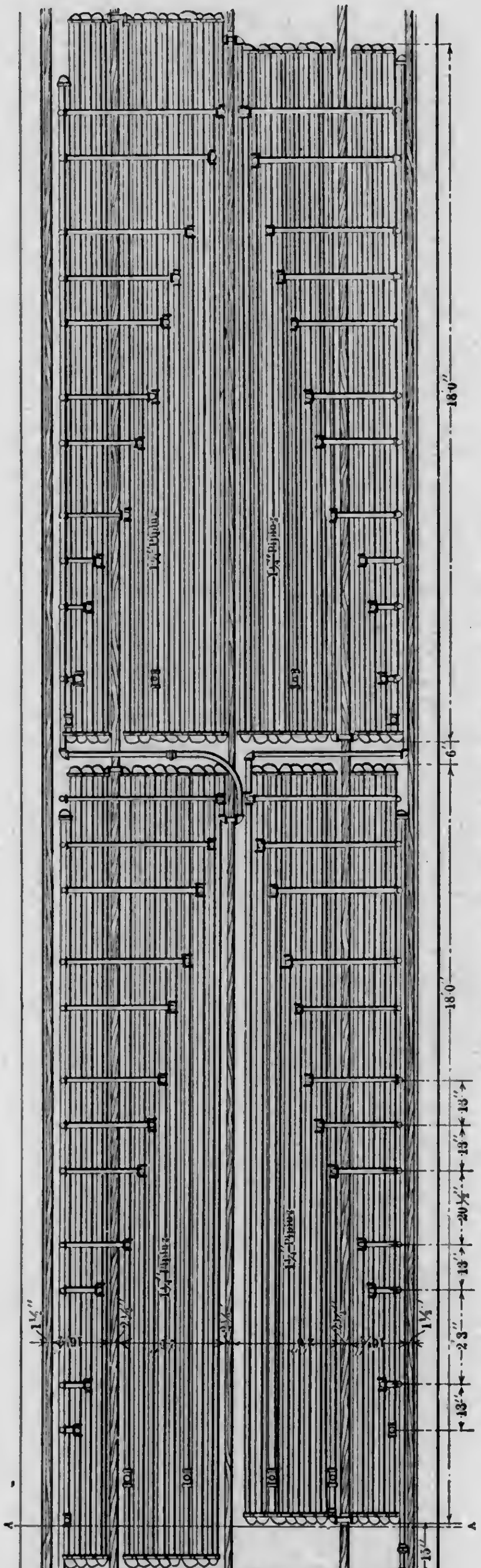
In addition to the usual method of ventilation three hatchways fitted with hinged covers have been arranged in the center of the roof. No accommodations for cooking have been provided, since the car will always be located at points where hotel accommodation can be secured.

The underframe consists of eight 5 x 8 in. wooden sills, the side sills being reinforced by ⅝ x 7 in. iron plates. Four truss rods are included and the window posts are made solid, so as to provide secure support for the brake cylinder brackets. The lighting is by Pintsch gas and the car is also wired for electric lights, the current being obtained from the circuits at the various shops.

This car and the arrangement of its equipment was designed by Mr. B. P. Flory, mechanical engineer, and Mr. G. W. Rink,



SECTION SHOWING PIPING.



ARRANGEMENT OF PIPES ON FLOOR OF INSTRUCTION CAR—CENTRAL RAILROAD OF NEW JERSEY.

INTERIOR OF AIR BRAKE INSTRUCTION CAR—C. R. R. OF N. J.

chief draftsman, under the supervision of Mr. William McIntosh, superintendent of motive power. It has the following general dimensions:

Length over end sills	70 ft.
Width over side sills	9 ft. 8 in.
Length of instruction room	52 ft. 2 in.
Length of office	13 ft.
Truck, type	Six wheel, 5 x 9 in. journals
Weight of car, complete	150,000 lbs.

LUBRICATION OF AIR COMPRESSORS AND PNEUMATIC TOOLS.

The lubrication of compressors and pneumatic tools is a feature deserving careful attention. A too frequent mistake is made by using in air cylinders of compressors oil intended for steam cylinders. Such oil is of low flash point, whereas, the power lubrication of air cylinders demands a light oil of high flash point and of very best quality. Oil of poor grade and low flash point becomes vaporized in air cylinders and is discharged with the air without effecting lubrication.

Oil should be fed to air cylinders slowly and sparingly, as too much oil will clog the air valves, causing them to stick and give trouble. Air valves should be examined and cleaned at intervals by washing in kerosene or naphtha. When this is done, the valves should be removed from the compressor. Engineers have been known to introduce kerosene through the air-inlet pipe, an effective method of cleansing dirty valves, but sometimes equally effective in producing an explosion, since the oil forms a fine spray or mist which, when compressed with the air, produces a condition similar to that in the cylinder of an oil engine.

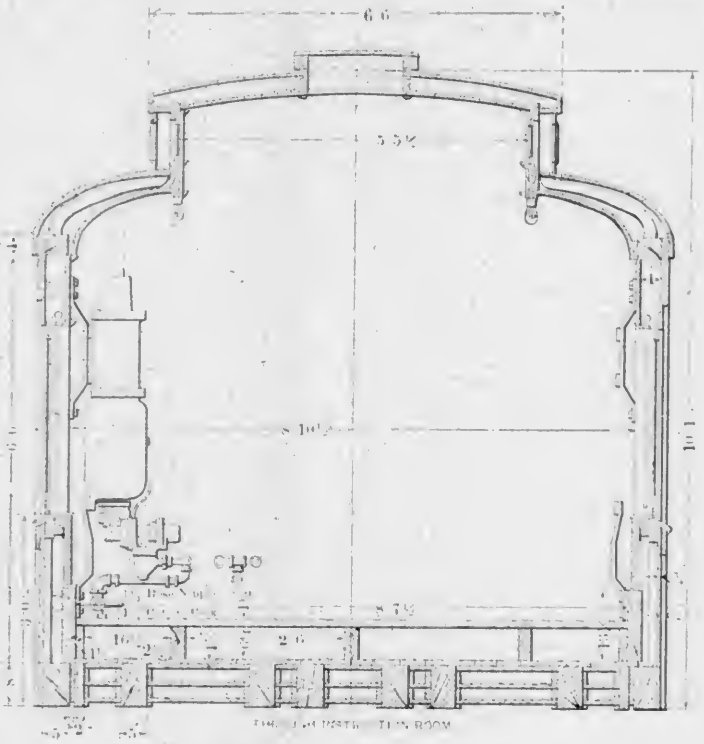
The feeding of soap-suds into the air cylinder through the lubricator is excellent for keeping valves clean, but when this is done oil should be fed through afterward to prevent rust.

The lubrication of pneumatic tools is of equal importance. One cannot do better than obtain and use one of the several brands of oil furnished by pneumatic tool makers who have made a special study of the requirements. Such oil is necessarily light, and under no circumstances should a heavy oil be used, as the cooling effect of the expanding air would cause it to clog the tool parts and prevent the free movement of the parts.

Pneumatic hammers should be carefully cleaned after using, and kept submerged in a tank of oil when not in service. An excellent device for effectively lubricating pneumatic tools is an automatic oiler inserted in the supply hose about 20 inches from the tool with oil-proof hose between oiler and tool, which, operating on the principle of an atomizer, enables the flow of the lubricant to be regulated to a nicety.—*Mr. W. P. Pressinger before the Central Railway Club.*

ELECTRO-PNEUMATIC BRAKE FOR RAILWAY TRAINS.—The January issue of the Bulletin of the International Railway Congress includes a description of a new electric brake, which has recently been devised by Messrs. Siemens & Halske, and which is arranged to properly proportion the brake pressure to the coefficient of friction, so that the maximum amount of braking power is obtained at all times. The apparatus is all supplementary to the regular air brake equipment of the Westinghouse type and includes an extra brake cylinder and reservoir on each car. The pressure in the former is regulated by an electric gear operated by a mercury inertia regulator. A three-wire circuit is carried throughout the length of the train and the proper electrical apparatus and connections are made at each car and on the locomotive, so that the supplementary electrical action will be entirely automatic for ordinary stops and give a pressure in addition to that of the regular application, which will be relieved as the speed is decreased. A connection is made to the engineer's valve, so that in case of an emergency stop both the air and electric appliances are thrown into full use.

INTERESTING LOCOMOTIVE CONSTRUCTION.—The pistons in the cylinders are connected to the four coupled driving wheels by a mechanism constructed according to most recent practice; in short, from piston rod to cross head through connecting rod to driver.—*Exchange.*



SECTION OF AIR BRAKE INSTRUCTION CAR.

proper number of brakes for a 5, 10, 20, 30, 40, 45 and 50 car train.

The illustration shows the arrangement of the apparatus and its piping. The 5 car passenger train is obtained by equipping five of the freight cylinders with a high speed reducing valve which can be cut in if desired. The 10-in. passenger brake cylinder, which has a slack adjuster and a P1 triple in tandem, is mounted upon a crane and can be swung out in front of the instructor's table. On the opposite side of the car is another crane supporting two 10 in. brake cylinders with K and L triples and sectional triples arranged in tandem. The air signal instruction apparatus consists of a 12 car train equipment, and is located under the lower deck on each side.

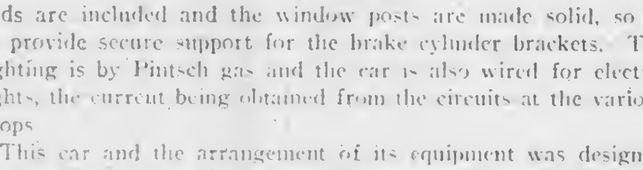
The instruction table is equipped with a No. 6 E T valve complete with a distributing valve working in tandem; also a G6 engineer's valve, which can be used with or without straight air.

All of this apparatus can be arranged for high speed brakes. The 9½-in. air pump provided can be operated by steam or air, either direct or compound, thus being able to furnish any desired air pressure. This pump is operated by steam or air connections from pipe lines at the various shops or stations, no boiler being provided in the car. The auxiliaries for the driver, tender and passenger cylinders are located under the car.

In addition to the usual method of ventilation three hatchways fitted with hinged covers have been arranged in the center of the roof. No accommodations for cooking have been provided, since the car will always be located at points where hotel accommodation can be secured.

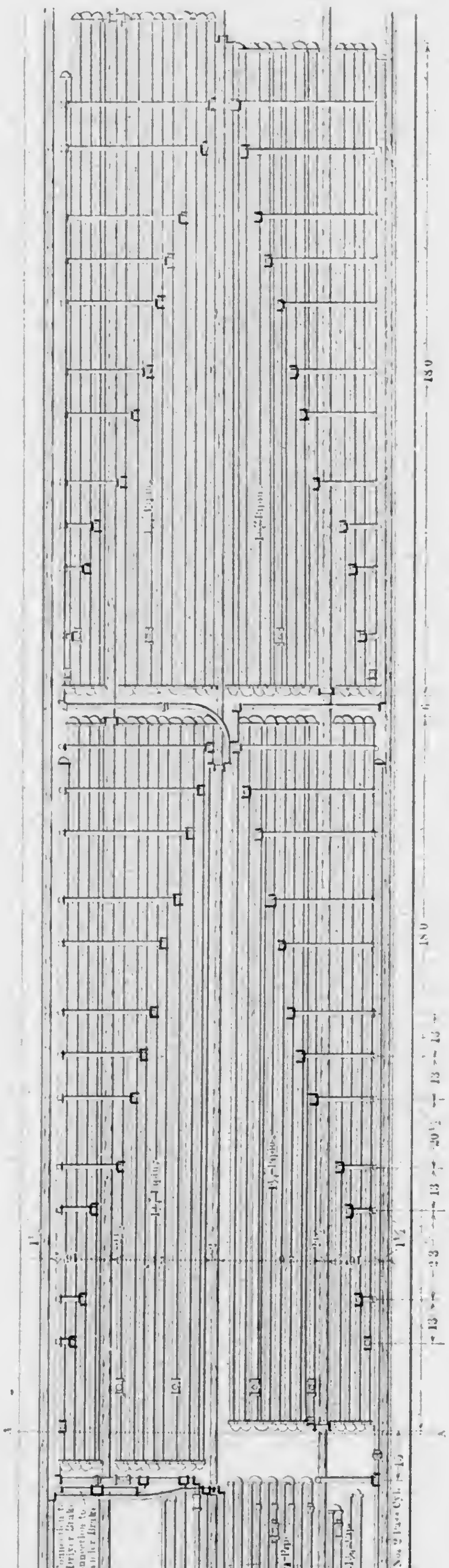
The underframe consists of eight 5 x 8 in. wooden sills, the side sills being reinforced by 5/8 x 7 in. iron plates. Four truss rods are included and the window posts are made solid, so as to provide secure support for the brake cylinder brackets. The lighting is by Pintsch gas and the car is also wired for electric lights, the current being obtained from the circuits at the various shops.

This car and the arrangement of its equipment was designed by Mr. B. P. Flory, mechanical engineer, and Mr. G. W. Rink,



Section at A A

SECTION SHOWING PIPING.



ARRANGEMENT OF PIPES ON FLOOR OF INSTRUCTION CAR—CENTRAL RAILROAD OF NEW JERSEY.

INTERIOR OF AIR BRAKE INSTRUCTION CAR—C. R. R. OF N. J.

chief draftsman, under the supervision of Mr. William McIntosh, superintendent of motive power. It has the following general dimensions:

Length over end sills	70 ft.
Width over side sills	9 ft. 8 in.
Length of instruction room	52 ft. 2 in.
Length of office	15 ft.
Truck, type	Six wheel, 5 x 9 in. journals
Weight of car, complete	150,000 lbs.

LUBRICATION OF AIR COMPRESSORS AND PNEUMATIC TOOLS.

The lubrication of compressors and pneumatic tools is a feature deserving careful attention. A too frequent mistake is made by using in air cylinders of compressors oil intended for steam cylinders. Such oil is of low flash point, whereas the power lubrication of air cylinders demands a light oil of high flash point and of very best quality. Oil of poor grade and low flash point becomes vaporized in air cylinders and is discharged with the air without effecting lubrication.

Oil should be fed to air cylinders slowly and sparingly, as too much oil will clog the air valves, causing them to stick and give trouble. Air valves should be examined and cleaned at intervals by washing in kerosene or naphtha. When this is done, the valves should be removed from the compressor. Engineers have been known to introduce kerosene through the air-inlet pipe, an effective method of cleansing dirty valves, but sometimes equally effective in producing an explosion, since the oil forms a fine spray or mist which, when compressed with the air, produces a condition similar to that in the cylinder of an oil engine.

The feeding of soap-suds into the air cylinder through the lubricator is excellent for keeping valves clean, but when this is done oil should be fed through afterward to prevent rust.

The lubrication of pneumatic tools is of equal importance. One cannot do better than obtain and use one of the several brands of oil furnished by pneumatic tool makers who have made a special study of the requirements. Such oil is necessarily light, and under no circumstances should a heavy oil be used, as the cooling effect of the expanding air would cause it to clog the tool parts and prevent the free movement of the parts.

Pneumatic hammers should be carefully cleaned after using and kept submerged in a tank of oil when not in service. An excellent device for effectively lubricating pneumatic tools is an automatic oiler inserted in the supply hose about 20 inches from the tool with oil-proof hose between oiler and tool, which, operating on the principle of an atomizer, enables the flow of the lubricant to be regulated to a nicety.—*Mr. W. [illegible] in a paper before the Central Railway Club.*

ELECTRO-PNEUMATIC BRAKE FOR RAILWAY TRAINS.—The January issue of the Bulletin of the International Railway Congress includes a description of a new electric brake which has recently been devised by Messrs. Sanders & [illegible], which is arranged to properly proportion the brake pressure to the coefficient of friction, so that the maximum amount of braking power is obtained at all times. The equipment is supplementary to the regular air brake equipment of the Westinghouse type and includes an extra brake cylinder and reservoir on each car. The pressure in the former is regulated by an electric valve operated by a mercury inertia regulator. A [illegible] circuit is carried throughout the length of the train and the necessary electrical apparatus and connections are made on each car and on the locomotive, so that the supplementary [illegible] will be entirely automatic for ordinary stops and give a pressure in addition to that of the regular application which will be released as the speed is decreased. A connection is made to the engineer's valve, so that in case of an emergency stop both the air and electric appliances are thrown into full use.

INTERESTING LOCOMOTIVE CONSTRUCTION.—The pistons in the cylinders are connected to the four coupled driving wheels by a mechanism constructed according to most recent practice; in short, from piston rod to cross head through connecting rod to driver.—*Exchange.*

SUPERHEATED STEAM FOR LOCOMOTIVES.*

By Robert Garbe.†

Among the improvements in locomotive construction none has excited greater interest in professional circles than the application of highly superheated steam in current locomotive practice. Ten years ago few, even among the most far-seeing of practical locomotive engineers, were willing to admit of the possibility of permanently and regularly producing steam at temperatures of 550 to 650 degs. F. within the restricted capacity of an ordinary locomotive boiler and of its safe and economical application to the ordinary running of an engine; while at the present time it has found successful application in more than 2,000 locomotives, if we include those in construction with those actually running. Dry or moderately superheated steam has been tried on different occasions, but without realizing any notable economic advantage in practice, and it was not until Mr. William Schmidt, of Cassel, had developed practical methods of applying high superheat that its use became possible in stationary engines about 1880, while fifteen years later the first steps were taken in extending it to locomotives.

From the beginning of the trials which were made at this time on the Prussian State Railways it became apparent that an effective locomotive superheater could only be realized by making it a closely connected integral part of the boiler itself, receiving its heat from the live flames of the fire grate and not from waste gases or an independently fired apparatus.

Properties of Hot Steam.—According to Schmidt the term "hot steam" is to be understood as meaning steam that has been raised to 180 degs. F. above its proper saturation temperature. An appreciation of the method of producing and using superheated steam will be much facilitated by a preliminary consideration of the more important properties in which it differs from saturated steam.

The specific volume of saturated steam diminishes with increase of temperature, while on the other hand the volume of superheated steam increases nearly directly in proportion to the rise of temperature. The specific volume for superheat of 200 degs. is increased approximately 25 per cent., and thus for the same cut-off in the cylinder the weight of steam required is about 25 per cent. less with 200 degs. superheat than with saturated steam with the same pressure.

This augmentation of volume is, however, a less important advantage than that realized by the suppression of all cylinder condensation when the superheat is sufficiently high. Under ordinary average working conditions with saturated steam about 35 per cent. of the total quantity admitted immediately precipitates without doing any mechanical work and passes through the engine as suspended water in the steam. Highly superheated steam, on the contrary, does not lose any of its capacity as a working agent. This condition is augmented by the low thermal conductivity of the superheated steam; while saturated steam is a good conductor of heat, highly superheated steam is a very bad conductor. This property, which is of great value in reducing the loss by cooling in the cylinders, is, on the other hand, an obstacle to the free transmission of the heat to the steam in the superheater and calls for special consideration in its design.

In order to realize the great economical advantage of hot steam, increased volume and avoidance of cylinder condensation, a certain heat expenditure must be debited to the saving due to the above items.

The heat necessary to rise one pound of saturated steam from its proper temperature T to a higher temperature t degrees F is:

$$W_1 = C\ (t - T)\ \text{B.T.U.}$$

C being the specific heat of the superheated steam under constant pressure.

Putting W equal to the quantity of heat contained per pound of steam saturated at this particular pressure, then $W_2 = W + W_1 = W + C\ (t - T)$ expresses the heat value of the superheated steam; that is, the total heat contained in one pound of steam superheated to the temperature t.

According to the latest researches the specific heat of steam is not constant, but varies with the temperature and pressure. The mean values for the temperatures and pressures current in locomotive practice are shown in the following table:

Pressure	128	156	185	213
Saturation temperature	354° F.	369° F.	381° F.	392° F.
Specific heat at temperature 392° F.	.597	.635	.677	......
" " " " 482° F.	.552	.570	.588	.609
" " " " 572° F.	.530	.541	.550	.561
" " " " 662° F.	.522	.529	.536	.543

The heat requirements of the superheater are not limited to the amount W_1 necessary for supplying the actual superheat, but must be supplemented by the quantity for evaporating particles of water mechanically carried into the superheater. Assuming a degree of humidity in the boiler steam of 7 per cent., which for ordinary locomotive working conditions is certainly not excessive, the heat demand for the production of one pound of steam at 170 lbs. pressure and 572 degs. F., temperature from the heating surface of the boiler and superheater, will be as follows:

	B. T. U.
From the boiler surface:—	
.93 lb. dry saturated steam = .93 × 1,194.3 =	1,111
.07 lb. water at saturation temp. = .07 × 340.5 =	24
	1,135
From the superheater:—	
Evaporation of .07 lb. water at 368.3° F = .07 × 853.8 =	60
Superheating 1 lb. dry steam by 204° = .541 × 204 =	110
Total heat required for 1 lb. of hot steam =	1,305

of which 170 or 13 per cent is required from the superheater.

Assuming that 40 per cent. of the total heat is developed in the fire-box and 60 per cent in the tubes, the superheating surface would therefore be 13 per cent. of 60 or 22 per cent. of the total tube surface, and when it is further considered that the best part of this surface nearest to the back tube sheet is unavailable it is readily understood that in order to obtain a sufficient superheat, from 25 to 30 per cent. of the total tube surface of the boiler must be appropriated to that use.

It by no means follows that the superheating surface is directly proportional to the degree of superheat, since to require half of the heat, or to say 473 degs. F., considerably more work is called for than will be furnished by a superheater of only half the heating surface.

Generation of Superheated Steam.—The valuable property of poor thermal conductivity, characteristic of highly superheated steam, is a source of great difficulty in its production. Steam with only a moderate superheat is generally mixed with particles of water or damp steam, the better conductivity of which will rapidly contaminate the whole mixture. In order to supply the heat to all parts of the steam it is required that it shall be divided into numerous thin streams, which by combination with multiple reversals of direction will insure the thorough mixture of the moist and superheated particles. It is very necessary that a high temperature difference shall prevail. That is, the application of highly heated gases is essential.

According to the author's experience an average temperature of 570 degs. F. in the steam chest must be obtained in order to insure the homogeneity of the superheated steam or its freedom from intermixed damp or saturated portions. Repeated trials have shown that the coal and water consumption are decidedly increased when the temperature falls below that level to any extent.

Having regard to the small available space in a locomotive boiler, successful superheating can only be realized by superheaters complying with the following conditions: 1. Application of a sufficiently high temperature in the heating gases. 2. The greatest possible sub-division of the superheater surface. 3. Mixing the steam currents on their way through the tubes and lengthening the passages, so that they are compelled after passing one set of tubes to return by another. 4. Guiding and regulating the draft of the heating gases.

Hauling Capacity Increased.—In addition to a saving in fuel and water a further and more important advantage of superheated steam working is to be found in the notable increased

* Abstract of a series of articles published in the *Engineer* (London) on October 25, November 1, 8, 15, 22, 29 and December 6, 1907.

† Privy Counselor, Prussian State Railways.

hauling capacity of the engine. In comparative trials of two locomotives the superheated engine often showed a saving of about 25 per cent. of coal, each doing the same amount of work. This locomotive could, however, be harder driven, doing about 40 per cent. more work than the other engine and would still give a coal consumption of 10 per cent. less. The superheat, therefore, is to be regarded not merely in the light of saving 25 to 30 per cent. of the coal but as a certain security against the wasteful and objectionable practice of using two engines in front of one train.

Forms of Superheaters.—The method of leading the currents, both of furnace gases and of steam, is of primary importance in determining the efficiency of superheaters. Care must be taken to protect the tubes from the cutting action of the flame and the counter current principle of bringing the coolest steam in contact with the hottest portion of the flues is essential. The question whether the tubes should be arranged transversely or parallel to the current of hot gases cannot be considered being finally settled. The experience with the stationary boilers, however, would indicate that the latter is more favorable to regularity in heating.

The superheater system must include the largest possible number of thick small bore tubes to allow of frequent intermixture of the currents, taking care, however, that steam that has already been superheated should not be brought into contact with that in a damp or saturated condition.

The velocity of the steam in the superheater must be tolerably high in order to prevent overheating the tubes. The upper limit of such velocity is determined by the permissible fall in pressure and is considerably higher than with saturated steam on account of the increased fluidity due to the complete gasification.

Eliminating Condensation.—The conditions holding for working, with saturated steam, which compel the condensation of considerable of the entering steam, which is later evaporated and passes through the cylinder without doing any work and may even, if the piston speed is sufficiently high, remain as water in the cylinder, are advantageously modified when a sufficient degree of superheating is adopted. The heat exchanges during admission, with superheated steam, take place at the cost of the surplus above the saturation temperature, and while the steam is somewhat cooled, it is not sufficient to cause condensation. The loss of working power, due to the contracted volume caused by such cooling, is unimportant. During the exhaust the heat demand on the cylinder walls is comparatively small, especially when a slight superheat still remains, partly because such steam is a poor conductor of heat, and particularly because such heat is directly applied to raising the steam temperature and not for evaporating water. The use of hot steam, therefore, is attained with a much smaller heat interchange and the mean temperature of the cylinder walls is kept at a higher point.

It must, however, be borne in mind that it is only by a very high initial superheating of the steam that cylinder condensation can be prevented during the entire working stroke, and this has been objected to on the ground that with such excessive heating the superheat is not entirely expended and the exhaust passes out at an unnecessarily high temperature. Upon these grounds it has been proposed to limit the superheat so that at the end of the stroke the exhaust will be in a saturated state. The constantly varying demands upon both the boiler and engine of a locomotive necessitate a considerable margin in the power of the superheater above that calculated for normal use and it would hardly be satisfactory to design a superheater to give this condition. Experiments made by Prof. Seeman on a stationary engine show that the heat consumption per indicated horse power fell continuously with each increment of heat of the live steam, notwithstanding the higher temperature of the exhaust, and although similar experiments have not been carried out with locomotives, the numerous trials made by the author have shown that the greatest economy is invariably obtained with the highest steam temperature, notwithstanding the increased temperature of the exhaust steam consequent upon its use.

In order to utilize the increased working power of the boiler, obtained by the addition of the superheater, most completely and economically it is not sufficient to merely increase the length of the admission in the cylinder above that calculated for saturated steam, as the losses due to insufficient expansion and increased back pressure will go far to counterbalance the saving. It is only by an appropriate enlargement in cylinder diameter that the tractive effort, while maintaining an economic figure of admission, can be augmented sufficiently to completely utilize the increased working capacity of the boiler. To realize this the cylinder diameter must be such that the maximum tractive effort is obtained with about 45 per cent. admission and the highest sustained working with 30 per cent. For minimum admission 20 per cent. is the lowest permissible, below that point the working must be regulated by throttling.

The conditions with saturated steam are entirely different. In order to reduce condensation losses the cylinder dimensions must be kept as low as possible, which necessitates a wasteful rate of admission when extra power is required, and it is upon this difference that the superiority of superheated steam depends. Its recognition, as a result of the continuous development of the application of superheating in locomotive construction on the Prussian State Railways, has led to a progressive enlargement of the cylinders. The so-called "characteristic C" of the Prussian hot steam 2-cylinder locomotives is as follows:

$$C = \frac{d^2 l}{D R}$$

where

d = diameter of cylinder in inches
l = length of stroke in inches.
D = diameter of driving wheels.
R = load on driving axle in tons.

This figure lies between 3.9 and 4.7, or considerably higher than is customary, or possibly with saturated steam locomotives. The boiler pressure is 170 lbs. per sq. in.

It may be appropriate to mention, in regard to the difficulties anticipated by many railway experts, as likely to arise from the working parts when continuously running under highly superheated steam, that such difficulties have not, in the large number of locomotives now in use, given rise to any practical inconvenience. Minor difficulties have been completely overcome, and as far back as six years ago forms of pistons, piston valves, and stuffing boxes were settled, which have since proven to be perfectly durable under the highest steam pressures. Lubrication troubles have been eliminated by the use of oils of a sufficiently high flash point combined with a simple method of oiling under pressure.

Economy.—The saving in coal due to the suppression of cylinder condensation with a simple superheated engine approaches about 25 per cent. when compared with that of the saturated steam locomotive of the same weight and to 15 or 20 per cent. when compared with a two or four cylinder compound. For practical locomotive purposes coal consumption alone can be relied upon for comparison under present conditions. Rules have been given at various times for determining the saving available but this was all based on the assumption that the saving increases uniformly with the superheat, which, however, is not borne out by the author's experience, as a notable saving is not realized with less than 100 degrees of superheat, and above that point it increases very rapidly.

[Following this Herr Garbe considers the subject of compounding vs. superheating and then discusses the different designs of superheaters and gives some details of locomotives using superheated steam. The series closed with the account of a number of comparative tests. We will publish an abstract of these chapters in a later number.—ED.]

EXAMINATION FOR APPRENTICE DRAFTSMEN, U. S. WAR DEPARTMENT.—The U. S. Civil Service Commission announces that an examination will be held on March 4, 1908, at all of the more important cities of the United States, to secure eligibles to the position of apprentice draftsmen, to fill vacancies in the War Department. These positions pay from $30 to $60 a month and an apprentice may enter an examination for the position of draftsmen, where the salary to start is from $1,000 to $1,200 a year. The age limit is from 17 to 21 years.

(Established 1832).

AMERICAN ENGINEER AND RAILROAD JOURNAL.

PUBLISHED MONTHLY

BY

R. M. VAN ARSDALE

J. S. BONSALL,
Business Manager.

140 NASSAU STREET, NEW YORK

R. V. WRIGHT,
E. A. AVERILL, } **Editors.**

MARCH, 1908

Subscriptions.—*$2.00 a year for the United States and Canada; $2.50 a year to Foreign Countries embraced in the Universal Postal Union. Remit by Express Money Order, Draft or Post Office Order. Subscription for this paper will be received and copies kept for sale by the Post Office News Co., 217 Dearborn St., Chicago, Ill. Damrell & Upham, 283 Washington St., Boston, Mass. Philip Roeder, 307 North Fourth St., St. Louis, Mo. R. S. Davis & Co., 346 Fifth Ave., Pittsburg, Pa. Century News Co., 6 Third St., S. Minneapolis, Minn. W. Dawson & Sons, Ltd., Cannon St., Bream's Buildings, London, E. C., England.*

Advertisements.—*Nothing will be inserted in this journal for pay,* EXCEPT IN THE ADVERTISING PAGES. *The reading pages will contain only such matter as we consider of interest to our readers.*

Contributions.—*Articles relating to Motive Power Department problems, including the design, construction, maintenance and operation of rolling stock, also of shops and roundhouses and their equipment are desired. Also early notices of official changes, and additions of new equipment for the road or the shop, by purchase or construction.*

To Subscribers.—*The* AMERICAN ENGINEER AND RAILROAD JOURNAL *is mailed regularly to every subscriber each month. Any subscriber who fails to receive his paper ought at once to notify the postmaster at the office of delivery, and in case the paper is not then obtained this office should be notified, so that the missing paper may be supplied.*

When a Subscriber changes his address *he should notify this office at once, so that the paper may be sent to the proper destination.*

CONTENTS

A resolution was passed at the last meeting of the New York Railroad Club requesting the committee on subjects of the M. C. B. Association to bring the subject of standardization of parts of all steel cars up for consideration at the convention. This resolution grew out of the recommendation in Mr. A. M. Waitt's paper, and while the suggestion is not by any means new, it appears as if the time had arrived when some real action could be taken upon it.

The desirability of such standards is being more thoroughly appreciated as steel cars are becoming more numerous. When a steel car is damaged sufficiently to require it to be sent to the repair yards of a foreign road, it usually is in a condition to need some new parts and if, as is often the case, it differs greatly from the cars on the road doing the repairing, the delay in obtaining the proper shaped and sized parts is very serious and most aggravating to all concerned.

SUPERHEATERS.

Herr Robert Garbe, privy counsellor of the Prussian State Railways, has probably had a longer and more thoroughly practical experience with locomotive superheaters than any other railway man on either continent. While his published works give in great detail the results of his observations on locomotives and locomotive appliances, a series of articles which he recently contributed to the *Engineer* (London) on the subject of the application of highly superheated steam to locomotives, presented the matter connected with superheated steam in a comparatively brief and very clear-cut manner. These articles give the author's ideas on each separate phase of the subject and briefly recount reasons for his deductions. An abstract of part of this series of articles is given in this issue for the benefit of such of our readers as do not have access to the *Engineer*.

It will be seen that Herr Garbe does not consider steam to be superheated in the real sense until it is at least 180 degrees F. above the saturation temperature for the pressure. His experience has shown that below this point there is a very rapid falling off in the advantages to be gained. The fact mentioned, that a locomotive on the Prussian State Railways with steam superheated to this temperature was capable of developing 40 per cent. more power than a similar sized saturated steam compound locomotive, which power was obtained with 10 per cent. less fuel consumption, is a feature which is worthy of the most careful consideration.

DESIGN OF WALSCHAERT VALVE GEAR.

The Walschaert valve gear has passed through its trial period in this country and is now being generally applied to all middle and heavy weight power. There is no need to recount its advantages, as they are now too well known to every one to require comment. There is need, however, for our locomotive designers and draftsmen to give special heed to the details of this gear, as they will no doubt be required to design it for application to practically all types of locomotives.

As is natural in applying an entirely new arrangement, the first attempts left considerable to be desired. Although the Walschaert valve gear had been in use abroad for a great many years, and its details there have been fully perfected, that fact proved to be of small value to us and the first attempts, based largely on foreign practice, were not altogether suited to our conditions. It has been necessary to strengthen, stiffen and simplify each successive application as the weak points have been developed by the very hard service under American conditions, intensified by serious traffic congestion. We believe now, however, that this period has passed and the present designs of this gear being applied have eliminated all of the serious shortcomings and can safely be taken as a basis and guide for the evolving of designs in the railroad drafting rooms. In this issue we are giving most of the important details of two different designs of the gear, one from each of the larger locomotive companies, both of which we believe to be good examples. In an earlier number we gave

similar details from a design on the Canadian Pacific Railway, in which it replaced the Stephenson gear on a standard locomotive, which conditions introduced many difficulties not present when the whole locomotive is being designed.

The three most important features of this type of gear, after the general arrangement has been laid out to give the best movement of the valve, are found in the necessity for providing as rigid a support as possible, in the provision for reducing wear to a minimum, and in providing sufficient lubrication at every point.

VANADIUM IN CAST IRON.

The improvement in the quality of steel by the addition of a small amount of vanadium has been given a great deal of attention by metallurgists and steel makers during the past year and the increased strength and non-fatiguing qualities of this material are now pretty generally known. There has not, however, appeared very much information concerning its effect on cast iron. It is but fair to assume that the action of vanadium on cast iron would be very similar to that on steel and if that actually proves to be the case, as seems evident, the field for improvement will be greatly extended. About the only figures from tests on cast iron that have come to our attention are found in a paper by Mr. Richard Moldenke, secretary of the American Foundrymen's Association, which are given in abstract on page 115 of this issue. While these are somewhat preliminary experiments they show that it is possible to increase the breaking strength of good machinery iron from 2,000 to 2,500 lbs. and of white iron from 1,500 to 3,900 lbs. These, of course, are wonderful results and if but one-half of the improvement can be obtained in regular foundry practice, the value to railroads and manufacturers will be exceedingly great. The largest field of usefulness of such iron would seem to be the cast iron wheel where, in spite of the recent increase in the thickness of the flange, there is still much room for improvement. Its possibilities in connection with locomotive cylinders, valve bushings and rings are also very attractive, as experience seems to indicate that the wearing qualities and the ability to take a high glazed finish while at the same time being soft and easy to machine, are present to a remarkable degree. Experiments in this field are now being carried on by one of the locomotive companies.

Ferro-vanadium in commercial shape ready for use in the foundry can now be obtained in practically unlimited quantities and at a price which will not prohibit its very general use.

A very costly conflagration occurred recently at one of our latest and best equipped locomotive terminal plants, in which the fire started in a shop structure between the two roundhouses and spread with great rapidity to the roofs of the latter. At this time both houses were filled with locomotives, some of which were under steam, and the final result was that sixteen locomotives were destroyed as far as fire can destroy them. Although this fire spread with unusual rapidity there was time to have saved a good portion of these engines had it not been for the fact that both turn-tables were put out of commission within a few minutes after the fire started. These turn-tables were driven by electric motors and obtained their power from wires which were run along with the lighting and other power circuits, on a row of short supports on the roof of the houses. These roofs being of wood soon caught fire, the wires were melted, and the operation of the turn-tables stopped.

This is not an unusual condition in roundhouses operated by electric turn-tables and is one which should be immediately corrected at all points. It is a simple matter to put the wires running to these turn-tables and motors underground and at the same time that this is being done a motor driven capstan or reel should be provided on each turn-table, so that in case of fire, engines which are not under steam could be drawn on to the table. This arrangement would also, no doubt, prove to be very valuable at other times for moving dead engines, tanks, etc.

PRACTICAL WORK IN CONNECTION WITH COLLEGE TRAINING.

To the Editor:

I have read with much interest the editorial in your January number, entitled, "Practical Work in Connection with College Training." My own experience has shown me the importance of work in the shop, or office, as a preliminary to teaching, or executive work. I have found the lessons learned during the five years which I spent as a machinist, before and after entering college, of almost incalculable benefit. An interregnum of three years in my college work, when I was assistant manager of a large manufacturing company in the east, opened up another field of valuable experience. I believe the fact is coming to be more generally recognized, that one who is teaching or leading young men along the ways of engineering should have traveled those ways with his own feet.

This is a natural reaction from the old idea of the college professor who was necessarily an indoor plant carefully kept from exposure to the rude blasts of the practical and business world. Nearly all of the engineering teachers at the Case School, and of those with whom I am acquainted here, have regular outside work in addition to their college duties and are employed as consulting engineers and experts with full recognition of their qualifications for such work. When there is this feeling in the engineering faculty, it is pretty sure to be communicated to the student body, giving a stimulus there towards good, sound, practical training.

I know that the majority of the students at the Case School, especially in the upper classes, found practical employment during vacations in shops and offices, as far as was possible, and that many of the men entering the institution were already good workmen in either wood or iron. Since reading your editorial, I have been interested in getting statistics with regard to the class which graduated here in 1907 and I enclose a list showing

CLASS OF 1907.

Number in Class	85
Number having had practical experience	65
Number of years experience:	
8 years and over	3
7 years	1
6 years	2
5 years	2
4 years	5
3 years	6
2 years	7
1 year and over	19
6 months and over	19
Nature of practical experience:	
Shop and drafting room	12
Drafting	3
Railway shops	23
Teaching and farming	2
Salesman	2

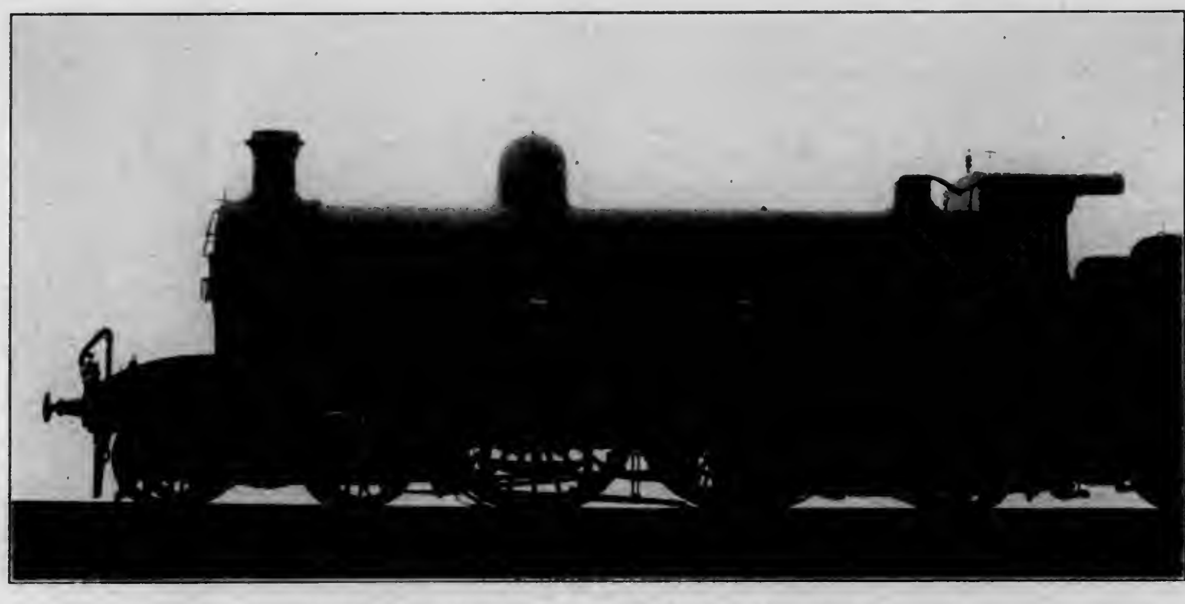
Other occupations, each represented by one student, were as follows: Machinist; concrete inspector; chemical laboratory; engineer, draftsman and telegraph operator; telephone work; bridge work and concrete construction; chemist; farming; manufacturing; lumber mill; bookkeeper; mail clerk, machinist, helper and farm hand; locomotive firing, drafting and farming; clerk; automobile work; civil work and shop; test department; shop and farming: shop and power plant; ranching.

the total number and the record of outside experience. There are two or three in the list who would not be regarded as having had experience which would be particularly helpful in the line of the profession, but the great majority have used their opportunities wisely.

A card index is kept of the Seniors and these figures are made up from the statements of the students themselves. I have no reason to doubt their reliability, and they show a state of things quite similar to that at Cornell. These men were mechanical engineers, but I have no doubt that a somewhat similar record could be made for those in the other engineering schools.

I well remember an address delivered by the late Professor Thurston, at one of the Case School commencements, in which he strongly advised the graduating class to take at least one year of postgraduate work. He concluded by saying: "I do not mean another year in college, but I mean for you to put on your jumpers and overalls and spend at least one year in contact with actual things in the shop." C. H. BENJAMIN.

Purdue University, Lafayette, Indiana.



FOUR CYLINDER SIMPLE LOCOMOTIVE—GREAT NORTHERN RAILWAY OF ENGLAND.

FOUR CYLINDER SIMPLE LOCOMOTIVE.

GREAT NORTHERN RAILWAY (ENGLAND).

CHAS. S. LAKE, A. M. I. MECH. E.

Among British railways the Great Northern is by far the largest user of the Atlantic (4-4-2) type of locomotive and to Mr. H. A. Ivatt, locomotive superintendent of that road, belongs the credit of having been the first to introduce the type in the United Kingdom.

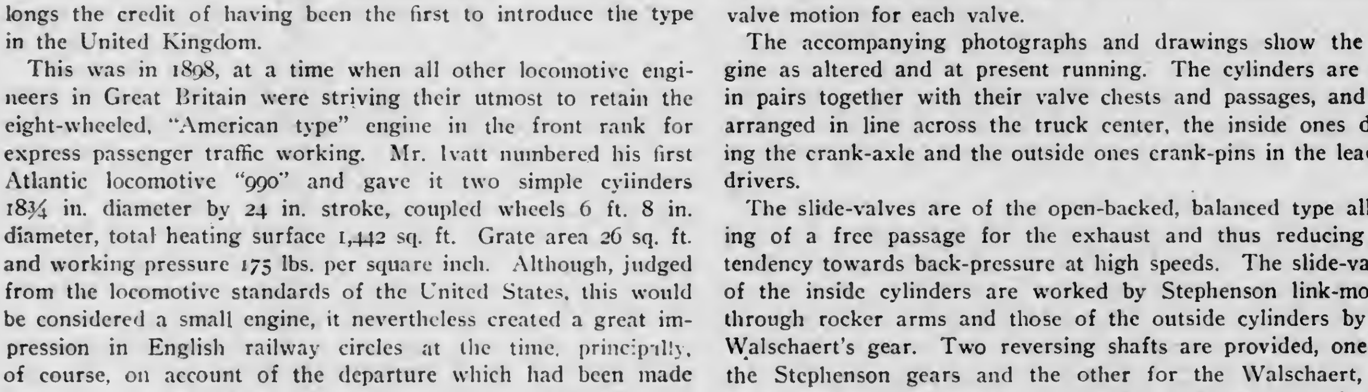
This was in 1898, at a time when all other locomotive engineers in Great Britain were striving their utmost to retain the eight-wheeled, "American type" engine in the front rank for express passenger traffic working. Mr. Ivatt numbered his first Atlantic locomotive "990" and gave it two simple cylinders 18¾ in. diameter by 24 in. stroke, coupled wheels 6 ft. 8 in. diameter, total heating surface 1,442 sq. ft. Grate area 26 sq. ft. and working pressure 175 lbs. per square inch. Although, judged from the locomotive standards of the United States, this would be considered a small engine, it nevertheless created a great impression in English railway circles at the time, principally, of course, on account of the departure which had been made from previous practice in the matter of type. The standard express locomotive of the largest class on the English Great Northern Railway at the present time is that known as the "251" class; simple, Atlantic type, with 5 ft. 6 in. diameter boiler and wide firebox, having a total heating surface of 2,500 sq. ft. and 30.9 sq. ft. of grate area. The proportions of the cylinders, wheels, etc., remain as in the "990" engines, which appear above.

One locomotive belonging to the "990" series and also one of the "251" engines have been built with four cylinders. In the first case the cylinders work single-expansion and in the second they are compounded. Engine No. 271 with four simple cylinders is, by Mr. Ivatt's courtesy, illustrated herewith. It is the only Atlantic locomotive in use on the Great Northern in which the forward coupled axle is exclusively employed for driving purposes. When this engine was first built, viz., in 1902, it was fitted with two sets of Stephenson link-motion only, for working the four slide-valves, which were of the piston type, and it ran in that condition for a considerable time. Later, in 1905, it was taken into the Doncaster shops of the G. N. Company and fitted with new cylinders having their valve chests above and independent valve motion for each valve.

The accompanying photographs and drawings show the engine as altered and at present running. The cylinders are cast in pairs together with their valve chests and passages, and are arranged in line across the truck center, the inside ones driving the crank-axle and the outside ones crank-pins in the leading drivers.

The slide-valves are of the open-backed, balanced type allowing of a free passage for the exhaust and thus reducing the tendency towards back-pressure at high speeds. The slide-valves of the inside cylinders are worked by Stephenson link-motion through rocker arms and those of the outside cylinders by the Walschaert's gear. Two reversing shafts are provided, one for the Stephenson gears and the other for the Walschaert, the same reach rod, screw, and handwheel, however, operating all four gears. The reversing shaft of the inside valve motion carries a coiled spring instead of the usual counterweights for neutralizing the weight of the link and its attachments.

The inside and outside cranks on each side of the engine are set 180 degrees apart and at 90 degrees in relation to the opposite pair of cranks, so that the two pistons on each side are always moving in opposite directions and there is a crank pin on every quarter. The main-rods are all of equal length, viz., 5 ft. 9¾ in. between centers and the throw of all cranks is 10 in. The crank-axle has journals 9 in. long by 8½ in. diameter and its

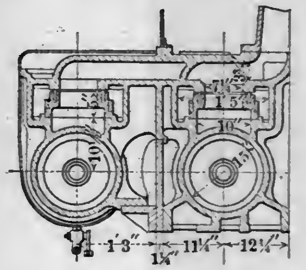


ELEVATIONS OF FOUR CYLINDER SIMPLE LOCOMOTIVE.

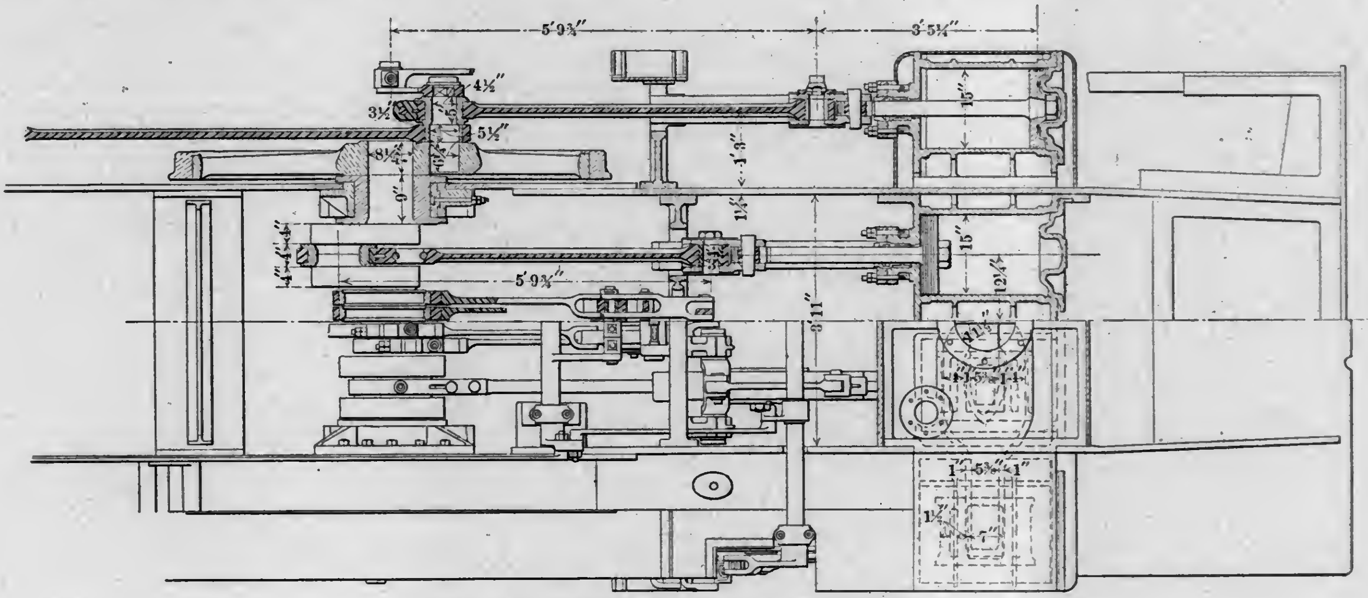
diameter at the central portion, between the two inside crank webs, is 7 in.

The crank webs are of the circular or disc pattern, with a diameter of 1 ft. 8¾ in. and a uniform thickness of 4 in. The distance between centers of journals is 3 ft. 9½ in. and between centers of inside crank pins 2 ft.. ½ in. The distance between centers of inside cylinders is 2 ft. ½ in. and the corresponding dimension for the outside cylinders is 6 ft. 7½ in.

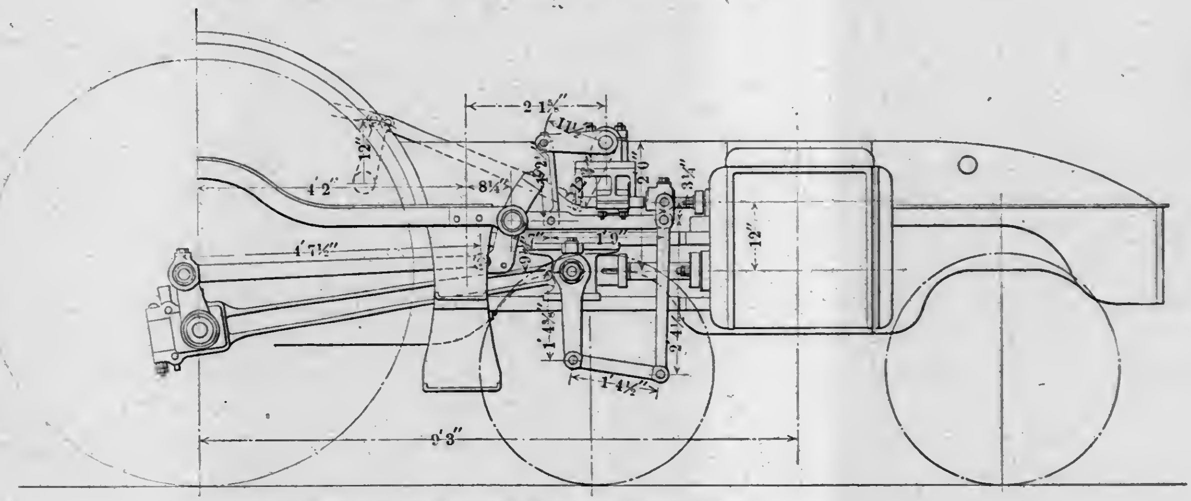
The front engine truck is of the swing-link type and lateral play is provided in the horn cheeks and boxes of the carrying wheels under the foot-plate which, unlike all the other wheels of the engine, have outside framing and axle boxes.



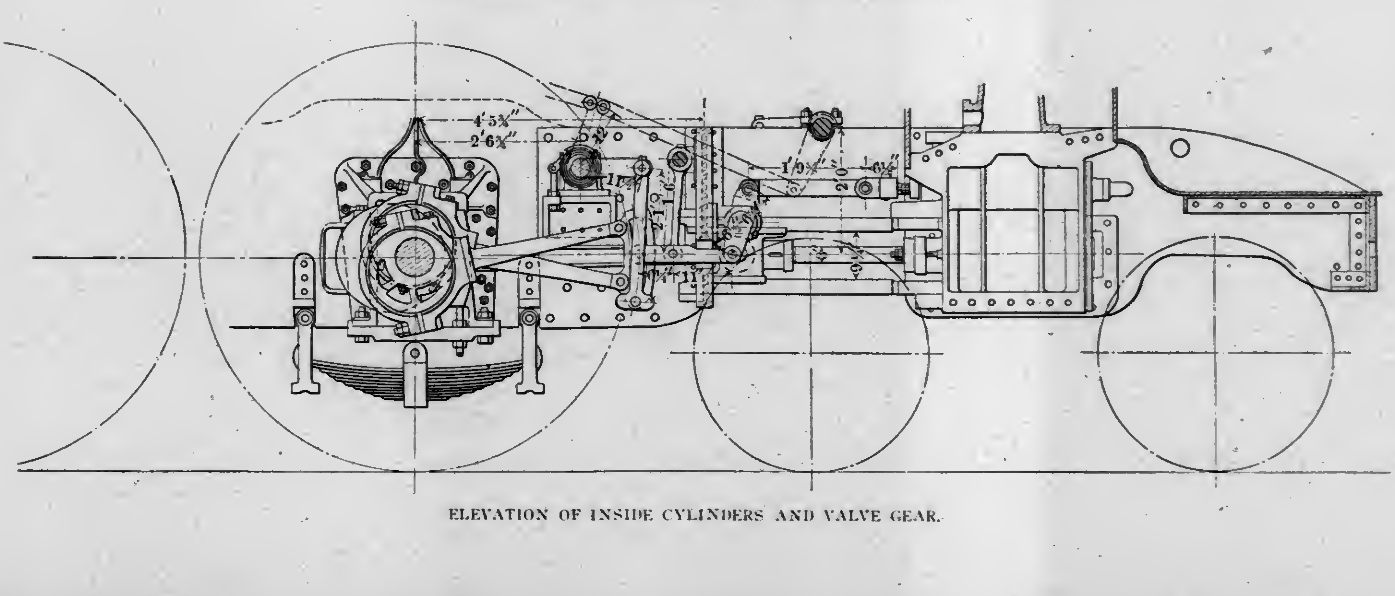
CROSS SECTION OF CYLINDERS.



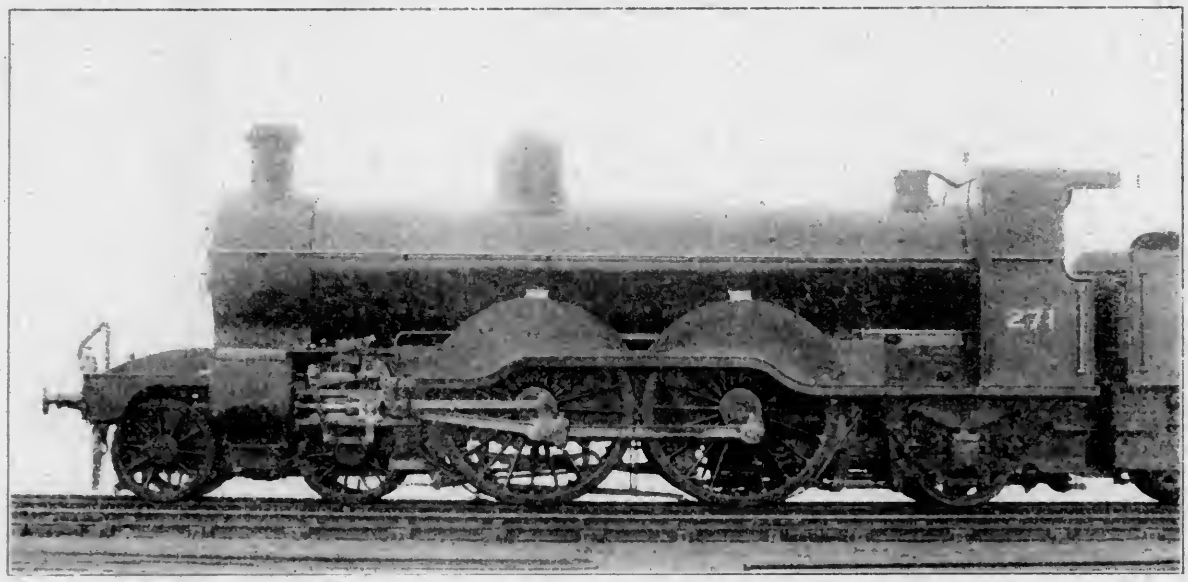
PLAN AND LONGITUDINAL SECTION OF RUNNING GEAR.



ELEVATION OF OUTSIDE CYLINDERS AND VALVE GEAR.



ELEVATION OF INSIDE CYLINDERS AND VALVE GEAR.



FOUR CYLINDER SIMPLE LOCOMOTIVE—GREAT NORTHERN RAILWAY OF ENGLAND.

FOUR CYLINDER SIMPLE LOCOMOTIVE.

GREAT NORTHERN RAILWAY (ENGLAND)

CHAS. S. LAKE, A. M. I. MECH. E.

Among British railways the Great Northern is by far the largest user of the Atlantic (4-4-2) type of locomotive and to Mr. H. A. Ivatt, locomotive superintendent of that road, belongs the credit of having been the first to introduce the type in the United Kingdom.

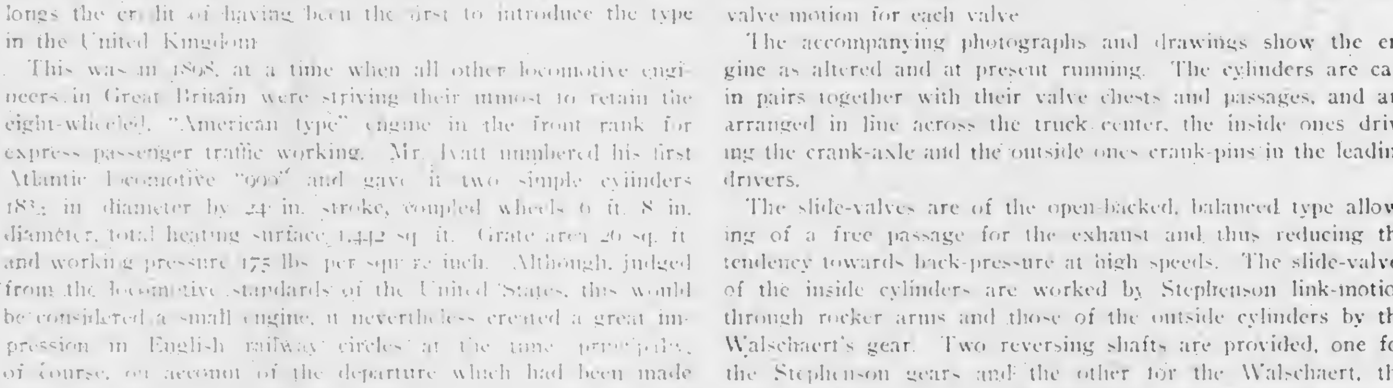
This was in 1898, at a time when all other locomotive engineers in Great Britain were striving their utmost to retain the eight-wheeled, "American type" engine in the front rank for express passenger traffic working. Mr. Ivatt numbered his first Atlantic locomotive "990" and gave it two simple cylinders 18¾ in diameter by 24 in. stroke, coupled wheels 6 ft. 8 in. diameter, total heating surface 1,442 sq. ft. Grate area 26 sq. ft. and working pressure 175 lbs per square inch. Although, judged from the locomotive standards of the United States, this would be considered a small engine, it nevertheless created a great impression in English railway circles at the time principally, of course, on account of the departure which had been made from previous practice in the matter of type. The standard express locomotive of the largest class on the English Great Northern Railway at the present time is that known as the "251" class; simple, Atlantic type, with 5 ft. 6 in. diameter boiler and wide firebox, having a total heating surface of 2,500 sq. ft. and 30.9 sq. ft. of grate area. The proportions of the cylinders, wheels, etc., remain as in the "990" engines, which appear above.

One locomotive belonging to the "990" series and also one of the "251" engines have been built with four cylinders. In the first case the cylinders work single-expansion and in the second they are compounded. Engine No. 271 with four simple cylinders is, by Mr. Ivatt's courtesy, illustrated herewith. It is the only Atlantic locomotive in use on the Great Northern in which the forward coupled axle is exclusively employed for driving purposes. When this engine was first built, viz., in 1902, it was fitted with two sets of Stephenson link-motion only, for working the four slide valves, which were of the piston type, and it ran in that condition for a considerable time. Later, in 1905, it was taken into the Doncaster shops of the G. N. Company and fitted with new cylinders having their valve chests above and independent valve motion for each valve.

The accompanying photographs and drawings show the engine as altered and at present running. The cylinders are cast in pairs together with their valve chests and passages, and are arranged in line across the truck center, the inside ones driving the crank-axle and the outside ones crank-pins in the leading drivers.

The slide-valves are of the open-backed, balanced type allowing of a free passage for the exhaust and thus reducing the tendency towards back-pressure at high speeds. The slide-valves of the inside cylinders are worked by Stephenson link-motion through rocker arms and those of the outside cylinders by the Walschaert's gear. Two reversing shafts are provided, one for the Stephenson gears and the other for the Walschaert, the same reach rod, screw, and handwheel, however, operating all four gears. The reversing shaft of the inside valve motion carries a coiled spring instead of the usual counterweights for neutralizing the weight of the link and its attachments.

The inside and outside cranks on each side of the engine are set 180 degrees apart and at 90 degrees in relation to the opposite pair of cranks, so that the two pistons on each side are always moving in opposite directions and there is a crank pin on every quarter. The main-rods are all of equal length, viz., 5 ft. 9¾ in. between centers and the throw of all cranks is 10 in. The crank-axle has journals 9 in. long by 8½ in. diameter and its

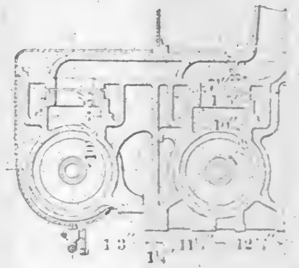


ELEVATIONS OF FOUR CYLINDER SIMPLE LOCOMOTIVE.

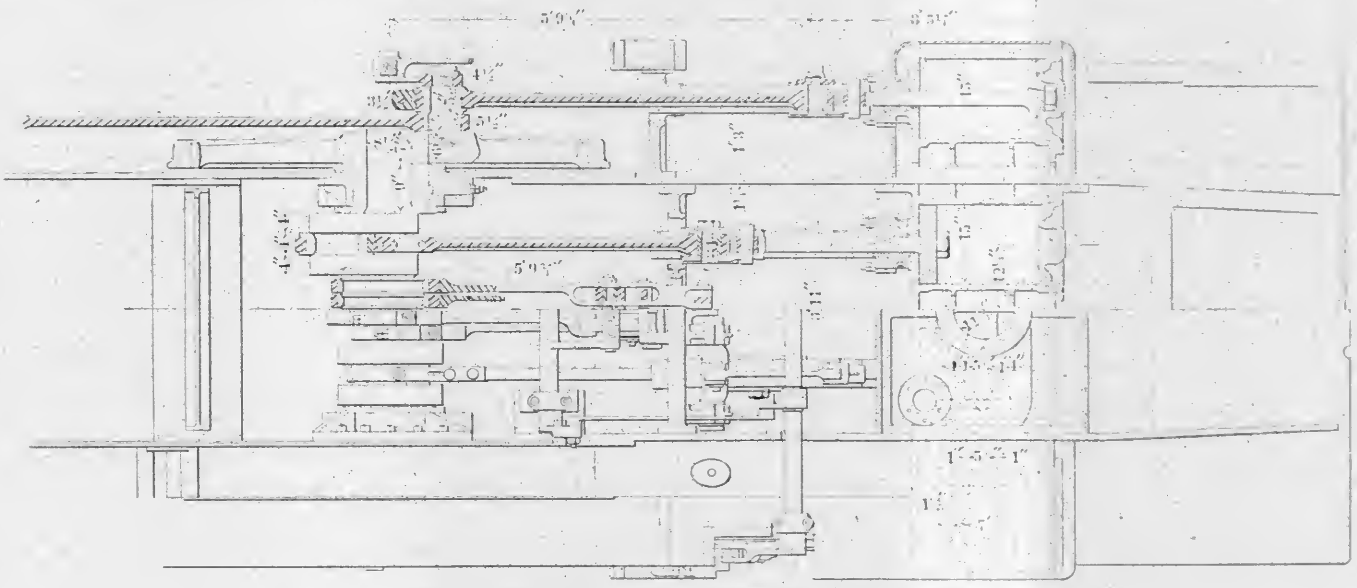
diameter at the central portion, between the two inside crank webs, is 7 in.

The crank webs are of the circular or disc pattern, with a diameter of 1 ft. 8¾ in. and a uniform thickness of 4 in. The distance between centers of journals is 3 ft. 9½ in. and between centers of inside crank pins 2 ft. ½ in. The distance between centers of inside cylinders is 2 ft. ½ in. and the corresponding dimension for the outside cylinders is 6 ft. 7½ in.

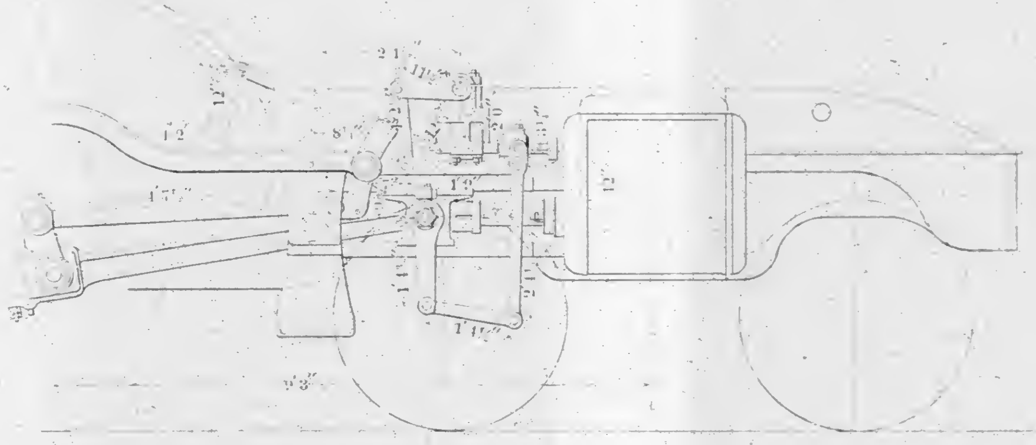
The front engine truck is of the swing-link type and lateral play is provided in the horn cheeks and boxes of the carrying wheels under the foot-plate which, unlike all the other wheels of the engine, have outside framing and axle boxes.



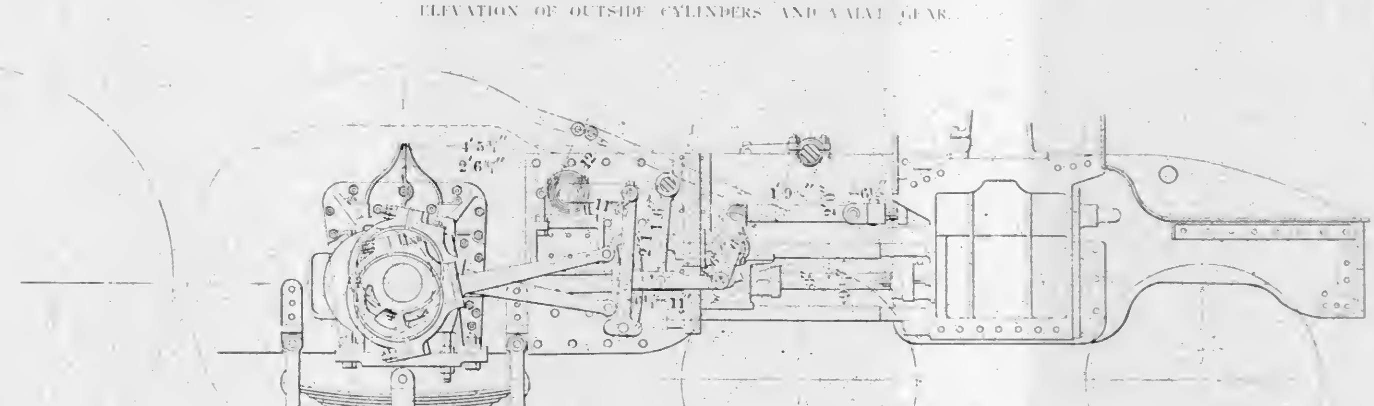
CROSS SECTION OF CYLINDERS.



PLAN AND LONGITUDINAL SECTION OF RUNNING GEAR.



ELEVATION OF OUTSIDE CYLINDERS AND VALVE GEAR.



ELEVATION OF INSIDE CYLINDERS AND VALVE GEAR.

The cylinder area of this engine is equal to that of two 21¼-in. diameter cylinders and the tractive effort is 113 lbs. to every 1 lb. of effective steam pressure on the pistons.

The boiler barrel and firebox outer shell are built of steel throughout and the interior firebox is of copper, radial stayed, with three expansion rows at the throat plate end of the crown sheet.

The front tube sheet is recessed back into the barrel for a distance of 1 ft. 11¼ in. from the forward extremity of the barrel. The boiler has a diameter outside of 4 ft. 8 in. and a length between tube plates of 14 ft. It is mounted with its axis 8 ft. 1¼ in. above rail level. The top of the firebox outer shell is semi-circular in shape and the extreme length over the firebox casing is 8 ft. The tender is of the Great Northern standard pattern on six 4-ft. 2-in. diameter wheels. It is fitted with water scoop actuated on Mr. Ivatt's patent hydraulic principle and carries 5 tons of coal and 3,670 gallons of water.

The engine is employed for working express passenger traffic on the Great Northern main line whereon speeds rule high and train weights, in the principal services, are unusually heavy for British railways. It has given every satisfaction in working, but no further locomotives of the same type have yet been built. The writer has had frequent opportunities for noting the performance of No. 271 and has invariably found the engine renders good service even with the fastest and heaviest trains. Still, no better results are obtained than from the larger boilered two-cylinder Atlantic type engines of the "251" class, which are, of course, more economical to maintain owing to their fewer parts. The coal consumption is about the same in both cases, but No. 271, as might be expected, uses more oil than its two-cylinder contemporaries.

The leading dimensions are as follows:

GENERAL DATA.

Gauge	4 ft. 8½ in.
Service	Passenger
Fuel	Bit. coal
Tractive effort	16,800 lbs.
Weight in working order	138,880 lbs.
Weight on drivers	79,520 lbs.
Weight on leading truck	34,720 lbs.
Weight on trailing truck	24,640 lbs.
Weight of engine and tender in working order	230,496 lbs.
Wheel base, driving	6 ft. 10½ in.
Wheel base, total	26 ft. 9 in.
Wheel base, engine and tender	48 ft. 11 in.

RATIOS.

Weight on drivers ÷ tractive effort	4.75
Total weight ÷ tractive effort	8.25
Tractive effort × diam. drivers ÷ heating surface	1,030
Total heating surface ÷ grate area	54.2
Firebox heating surface ÷ total heating surface, per cent	10.8
Weight on drivers ÷ total heating surface	61
Total weight ÷ total heating surface	106
Volume four cylinders	8.2 cu. ft.
Total heating surface ÷ vol. cylinders	159
Grate area ÷ vol. cylinders	3

CYLINDERS.

Number	4
Kind	Simple
Diameter and stroke	15 × 20 in.
Kind of valves	Bal. slide

WHEELS.

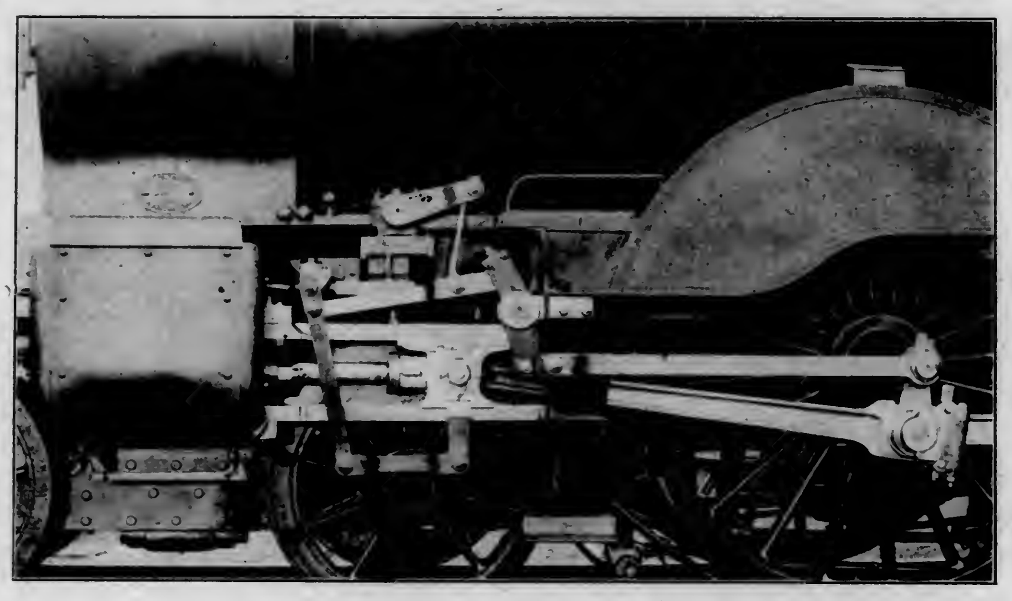
Driving, diameter over tires	80 in.
Driving journals, main, diameter and length	8½ × 9 in.
Engine truck wheels, diameter	44 in.
Trailing truck wheels, diameter	44 in.

BOILER.

Style	Straight
Working pressure	175 lbs.
Outside diameter of first ring	54 in.
Tubes, length	14 ft.
Heating surface, tubes	1,162.75 sq. ft.
Heating surface, firebox	140.25 sq. ft.
Heating surface, total	1,303 sq. ft.
Grate area	24.5 sq. ft.
Center of boiler above rail	97¼ in.

TENDER.

Weight	91,616 lbs.
Wheels, diameter	50 in.
Water capacity	3,670 gals.
Coal capacity	5 tons



VIEW SHOWING VALVE GEAR—FOUR CYLINDER SIMPLE LOCOMOTIVE.

THE ERA OF STEEL IN CAR CONSTRUCTION.

Mr. Arthur M. Waitt presented a very interesting and comprehensive paper on the subject of "The Era of Steel and the Passing of Wood in Car Construction" before the January meeting of the New York Railroad Club. The paper opened with a brief review of the history of the steel car and a consideration of its length of life, following which were some very striking figures on the growing shortness of the lumber supply, the influence of which is even now being felt. Following this Mr. Waitt spoke in part as follows:

"At the present time there are three distinctly different theories and systems in connection with the design for steel cars, each supported by able advocates. With one system the designers endeavor to carry the load on the side sills, using the center sills for buffing only. Another school of design endeavors to distribute the load nearly equally over all the sills. This design necessitates a somewhat heavier construction of car than the former. The third school of designers, which have the support of several car builders, endeavor to carry the load largely on the center sills, which are made very deep (even up to thirty inches); the center sills thereby not only carry the load but are also exceptionally strong to resist buffing.

"With the rapid introduction of steel car framing and its permanence in future practice, it seems at this time desirable as far as possible to eliminate the present great diversity of designs; for such diversity makes it impossible to keep the necessary parts in stock, for interchange repairs in the shops and repair yards of the various roads in the country. Not only is it desirable to simplify and eliminate this great diversity of design, but there are also many strong arguments for working toward a body framing in freight cars, which will permit of an underframing that is interchangeable for box cars, gondolas and flat cars. The system of body framing which carries the load largely on the center sills seems to have a basis which will readily make it possible to have the body framing interchangeable as above suggested.

"Much has been done in years past toward unifying and simplifying the design of wooden cars, and it would seem that sufficient experience has now been had with cars of all-metal construction, or at least of all-metal underframing, to warrant a determined step toward standardizing.

"It would seem desirable for the Master Car Builders' Association to devote considerable attention in the near future to eliminating these great differences in design and the unnecessary multiplicity of parts, and to lend its influence through its

recommendations toward greater uniformity in sizes and greater simplicity in design.

"It seems perfectly feasible at this time to adopt as recommended practice and later as standards some rolled and pressed sections, at least in the main members of the body framing. A move in this direction would before long be felt in increased simplicity and economy in interchange repairs. It would seem even possible at this time to adopt standards in lengths and widths for steel box, gondolas and flat cars, and then as a natural sequence many standard shapes and sizes would follow. It would also be practicable to standardize many of the rolled sections for angles and channels which are used in the superstructure of many styles of cars now being constructed.

"In freight and in passenger car construction during the development period in the past the cars were strengthened where found necessary and all sorts of makeshift methods and devices, such as truss rods, flitch plates, and the introduction of malleable for cast iron were made use of. All this was done to make the car stand up in service, with their increasing size, and the increased severity of the work imposed upon them. All these expedients proved ineffectual and unsatisfactory, and at this time the needs of our present-day service can only be met by a car with a steel body framing.

"During the past year one prominent road in the country has designed and constructed box cars with not only a steel underframing but also with a steel superstructure. This is a daring attempt to further develop 'the era of steel' for car construction, but the practice is one which would seem to be open to decided doubt as to the entirely satisfactory results that will be obtained in service. On first impression the observer might assume from the description or examination of the all-steel box car that it was in every way a decided advance step. It is to be hoped that railroads will very carefully consider the history of steel box cars both abroad as well as at home before going very heavily into their construction.

"In the construction of gondolas and flat cars, except where such cars are likely to be used in service for hot cinders, hot billets, or some similar lading, it would seem to the writer the wisest policy to use a wooden flooring rather than steel.

"With now some ten years of extensive use of steel underframe and all-steel freight cars the earlier arguments in favor of their almost universal adoption have been strengthened and broadened. Even if the lumber supply was likely to be ample in the future, there can be little justification in perpetuating the wooden car, either by large continued expenditures for the maintenance of light capacity cars or by ordering cars with a wooden body framing for present or future use.

"In a paper read before the New England Railroad Club in 1904 by Mr. John H. MacEnulty, the writer stated that: 'It has been determined by two of the largest railway systems of the country that the drawbar pull required to move a ton of freight in a properly constructed car of 100,000 lbs. capacity is 24 per cent. less than that required to move the same load in an average wooden car of 60,000 pounds capacity.'

"This is not only a strong argument in favor of steel car construction, but also for the use of large capacity cars.

"Ease of renewal of the worn or broken parts in cars of steel construction is a feature of considerable advantage in favor of such cars as compared with those made of wood.

"Another great advantage from the use of steel cars or cars with steel underframe in freight service is developed when trains are wrecked; for steel cars in wrecks withstand successfully punishment which would mean the total destruction of wooden cars. It has been found that the parts bent or torn in damaged steel cars can be readily renewed or put back in their original shape at a comparatively reasonable cost.

"Wooden cars are damaged yearly in large numbers to an extent which makes them unfit for service and not worth repairing. With steel cars such a condition is practically impossible."

"The cost of steel cars per ton of hauling capacity in general is less than with wooden cars. In wooden cars of high capacity it is found that the ratio of light weight to the carrying capacity is altogether too high for comparison with steel cars, if viewed from the basis of economy in operation.

"In cost of maintenance the steel car has a decided advantage. In meeting the requirements of service in the operating department again the steel car is decidedly the favorite. Steel cars are so much less liable to damage in service that in many cases where a wooden car would be rendered unfit to continue in use, a steel car will be free from any serious defects and will continue as a money earner and not become a money loser.

"The life of wooden cars built to-day must necessarily be shorter than those built fifteen years ago, for at the present time it is impossible to get lumber anywhere approaching in quality that which was required in first-class freight cars in 1892.

"Trains are now frequently being made up containing from sixty to eighty or more heavily loaded cars, weighing from 3,000 to 4,000 tons, and the severe service and strains to which the cars are subjected make the cost of necessary repairs to the wooden cars increase constantly. On roads having such heavy traffic and handling such long trains, or whose cars are likely to be handled in such trains, they can ill afford to spend much money for the heavy repairs and maintenance of wooden freight cars of under 60,000 pounds capacity, and it is clearly no longer profitable to build such cars, which are necessarily too lightly framed to operate in conjunction with the heavy capacity steel car.

"As showing the conclusions arrived at, on one of the prominent railway systems of the country, the writer has before him the report and recommendations made to the chief executive officer of the company at a recent date. The report recommends the retiring of 4,600 coal and coke cars ranging from nine to twenty-three years in age, and having from 40,000 to 60,000 pounds capacity.

"It was shown that these cars average a cost of $95.98 per year for repairs, or 37.8 per cent. of the average total value of the cars. The tonnage of these cars being compared with tonnage of new steel cars which have been used by the company in large numbers, when considered in connection with the first cost and the cost of maintenance of steel cars, and based on experience, showed conclusively that the company could buy 3,000 new steel cars having a total capacity 20 per cent. greater than that of the 4,600 wooden cars, and out of the amount that it would cost to maintain the wooden cars for one year they could pay 6 per cent. interest on the cost price of the new steel cars and have remaining over $215,000. A desire for the greatest economy for the owners of the roads will assure the substitution of a lesser number of larger capacity steel cars for old light capacity wooden ones.

"Although steel underframing and practically all-steel construction has been used for a number of years for about all of the various types of freight equipment, yet it is only during the past three years that much has been done in this country to adapt such construction to the various styles of passenger equipment.

"Very satisfactory designs have been developed for baggage and postal cars, as well as for suburban and regular passenger service, and within the past year also for Pullman sleepers. It is yet too early to predict the outcome, but it seems to the writer that in future development of the design for steel passenger equipment cars there may be a happy medium arrived at, and generally adopted, where the underframes and the superstructure framing will be of metal, but a reasonable use be made of wood or some fireproof substitute, other than metal, which will permit of a decorative treatment that is more pleasing to the eye than is the case where thin metal is used, and which will also have all of the reasonable and necessary elements of safety for those who entrust their lives in such cars.

"In the early days of steel cars the matter of repairs was looked upon with many misgivings by the average master car builder and car repair foreman. Experience in handling these cars in large numbers has shown that there was no cause for any uneasiness on this score. In the repairs of steel cars it is not necessary to employ specially trained labor, and very few extra tools or facilities are absolutely necessary, though, of course, a

The cylinder area of this engine is equal to that of two 21¼-in. diameter cylinders and the tractive effort is 113 lbs. to every 1 lb. of effective steam pressure on the pistons.

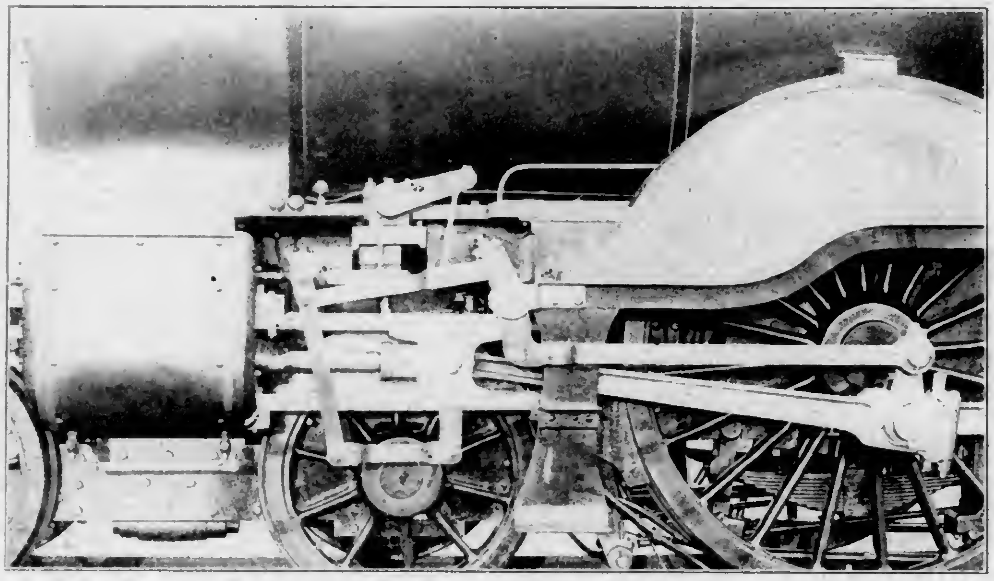
The boiler barrel and firebox outer shell are built of steel throughout and the interior firebox is of copper, radial stayed, with three expansion rows at the throat plate end of the crown sheet.

The front tube sheet is recessed back into the barrel for a distance of 1 ft. 11¼ in. from the forward extremity of the barrel. The boiler has a diameter outside of 4 ft. 8 in. and a length between tube plates of 14 ft. It is mounted with its axis 8 ft. 1½ in. above rail level. The top of the firebox outer shell is semi-circular in shape and the extreme length over the firebox casing is 8 ft. The tender is of the Great Northern standard pattern on six 4 ft. 2-in. diameter wheels. It is fitted with water scoop actuated on Mr. Ivatt's patent hydraulic principle and carries 5 tons of coal and 3,670 gallons of water.

The engine is employed for working express passenger traffic on the Great Northern main line whereon speeds rule high and train weights, in the principal services, are unusually heavy for British railways. It has given every satisfaction in working, but no further locomotives of the same type have yet been built. The writer has had frequent opportunities for noting the performance of No. 271 and has invariably found the engine renders good service even with the fastest and heaviest trains. Still, no better results are obtained than from the larger boilered two-cylinder Atlantic type engines of the "251" class, which are, of course, more economical to maintain owing to their fewer parts. The coal consumption is about the same in both cases, but No. 271, as might be expected, uses more oil than its two-cylinder contemporaries.

The leading dimensions are as follows:

GENERAL DATA.	
Gauge	4 ft. 8½ in.
Service	Passenger
Fuel	Bit. coal
Tractive effort	16,800 lbs.
Weight in working order	138,880 lbs.
Weight on drivers	79,520 lbs.
Weight on leading truck	31,720 lbs.
Weight on trailing truck	21,640 lbs.
Weight of engine and tender in working order	230,496 lbs.
Wheel base, driving	6 ft. 10½ in.
Wheel base, total	26 ft. 9 in.
Wheel base, engine and tender	48 ft. 11 in.
RATIOS.	
Weight on drivers ÷ tractive effort	4.75
Total weight ÷ tractive effort	8.25
Tractive effort × diam. drivers ÷ heating surface	1,030
Total heating surface ÷ grate area	54.2
Firebox heating surface ÷ total heating surface, per cent	10.8
Weight on drivers ÷ total heating surface	61
Total weight ÷ total heating surface	106
Volume four cylinders	8.2 cu. ft.
Total heating surface ÷ vol. cylinders	159
Grate area ÷ vol. cylinders	3
CYLINDERS.	
Number	4
Kind	Simple
Diameter and stroke	15 × 20 in.
Kind of valves	Bal. slide
WHEELS.	
Driving, diameter over tires	80 in.
Driving journals, main, diameter and length	8½ × 9 in.
Engine truck wheels, diameter	44 in.
Trailing truck wheels, diameter	44 in.
BOILER.	
Style	Straight
Working pressure	175 lbs.
Outside diameter of first ring	54 in.
Tubes, length	14 ft.
Heating surface, tubes	1,162.75 sq. ft.
Heating surface, firebox	140.25 sq. ft.
Heating surface, total	1,303 sq. ft.
Grate area	24.5 sq. ft.
Center of boiler above rail	97½ in.
TENDER.	
Weight	91,616 lbs.
Wheels, diameter	50 in.
Water capacity	3,670 gals.
Coal capacity	5 tons



VIEW SHOWING VALVE GEAR—FOUR CYLINDER SIMPLE LOCOMOTIVE.

THE ERA OF STEEL IN CAR CONSTRUCTION.

Mr. Arthur M. Waitt presented a very interesting and comprehensive paper on the subject of "The Era of Steel and the Passing of Wood in Car Construction" before the January meeting of the New York Railroad Club. The paper opened with a brief review of the history of the subject and a consideration of its origin in line, following which were given some striking figures on the growing shortage in the timber supply, the increase in cost as it is each year becoming less. Following this Mr. Waitt spoke in part as follows:

"At the present time there are three distinctly different theories and systems in connection with the design for steel cars, each supported by able advocates. With one system the designers endeavor to carry the load on the side sills, using the center sills for buffing only. Another school of design endeavors to distribute the load nearly equally over all the sills. This design necessitates a somewhat heavier construction of car than the former. The third school of designers, which have the support of several car builders, endeavor to carry the load largely on the center sills, which are made very deep (even up to thirty inches); the center sills thereby not only carry the load but are also exceptionally strong to resist buffing.

With the rapid introduction of steel car framing and its permanence in future practice, it seems at this time desirable as far as possible to eliminate the present great diversity of designs; for such diversity makes it impossible to keep the necessary parts in stock for interchange repairs in the shops and repair yards of the various roads in the country. Not only is it desirable to simplify and eliminate this great diversity of design, but there are also many strong arguments for working toward a body framing in freight cars, which will permit of an underframing that is interchangeable for box cars, gondolas and flat cars. The system of body framing which carries the load largely on the center sills seems to leave a basis which will readily make it possible to have the body framing interchangeable as above suggested.

"Much has been done in years past toward unifying and simplifying the design of wooden cars, and it would seem that sufficient experience has now been had with cars of all-metal construction, or at least of all-metal underframing, to warrant a determined step toward standardizing.

"It would seem desirable for the Master Car Builders' Association to devote considerable attention in the near future to eliminating these great differences in design and the unnecessary multiplicity of parts, and to lend its influence through its

recommendations toward greater uniformity in sizes and greater simplicity in design.

"It seems perfectly feasible at this time to adopt as recommended practice and later as standards some rolled and pressed sections, at least in the main members of the body framing. A move in this direction would before long be felt in increased simplicity and economy in interchange repairs. It would seem even possible at this time to adopt standards in lengths and widths for steel box, gondolas and flat cars, and then as a natural sequence many standard shapes and sizes would follow. It would also be practicable to standardize many of the rolled sections for angles and channels which are used in the superstructure of many styles of cars now being constructed.

"In freight and in passenger car construction during the development period in the past the cars were strengthened where found necessary and all sorts of makeshift methods and devices, such as truss rods, flitch plates, and the introduction of malleable for cast iron were made use of. All this was done to make the car stand up in service, with their increasing size, and the increased severity of the work imposed upon them. All these expedients proved ineffectual and unsatisfactory, and at this time the needs of our present-day service can only be met by a car with a steel body framing.

"During the past year one prominent road in the country has designed and constructed box cars with not only a steel underframing but also with a steel superstructure. This is a daring attempt to further develop 'the era of steel' for car construction, but the practice is one which would seem to be open to decided doubt as to the entirely satisfactory results that will be obtained in service. On first impression the observer might assume from the description or examination of the all-steel box car that it was in every way a decided advance step. It is to be hoped that railroads will very carefully consider the history of steel box cars both abroad as well as at home before going very heavily into their construction.

"In the construction of gondolas and flat cars, except where such cars are likely to be used in service for hot cinders, hot billets, or some similar lading, it would seem to the writer the wisest policy to use a wooden flooring rather than steel.

"With now some ten years of extensive use of steel underframe and all-steel freight cars the earlier arguments in favor of their almost universal adoption have been strengthened and broadened. Even if the lumber supply was likely to be ample in the future, there can be little justification in perpetuating the wooden car, either by large continued expenditures for the maintenance of light capacity cars or by ordering cars with a wooden body framing for present or future use.

"In a paper read before the New England Railroad Club in 1904 by Mr. John H. MacEnulty, the writer stated that: 'It has been determined by two of the largest railway systems of the country that the drawbar pull required to move a ton of freight in a properly constructed car of 100,000 lbs. capacity is 24 per cent. less than that required to move the same load in an average wooden car of 60,000 pounds capacity.'

"This is not only a strong argument in favor of steel car construction, but also for the use of large capacity cars.

"Ease of renewal of the worn or broken parts in cars of steel construction is a feature of considerable advantage in favor of such cars as compared with those made of wood.

"Another great advantage from the use of steel cars or cars with steel underframe in freight service is developed when trains are wrecked; for steel cars in wrecks withstand successfully punishment which would mean the total destruction of wooden cars. It has been found that the parts bent or torn in damaged steel cars can be readily renewed or put back in their original shape at a comparatively reasonable cost.

"Wooden cars are damaged yearly in large numbers to an extent which makes them unfit for service and not worth repairing. With steel cars such a condition is practically impossible."

"The cost of steel cars per ton of hauling capacity in general is less than with wooden cars. In wooden cars of high capacity it is found that the ratio of light weight to the carrying capacity is altogether too high for comparison with steel cars, if viewed from the basis of economy in operation.

"In cost of maintenance the steel car has a decided advantage. In meeting the requirements of service in the operating department again the steel car is decidedly the favorite. Steel cars are so much less liable to damage in service that in many cases where a wooden car would be rendered unfit to continue in use, a steel car will be free from any serious defects and will continue as a money earner and not become a money loser.

"The life of wooden cars built to-day must necessarily be shorter than those built fifteen years ago, for at the present time it is impossible to get lumber anywhere approaching in quality that which was required in first class freight cars in 1892.

"Trains are now frequently being made up containing from sixty to eighty or more heavily loaded cars, weighing from 3,000 to 4,000 tons, and the severe service and strains to which the cars are subjected make the cost of necessary repairs to the wooden cars increase constantly. On roads having such heavy traffic and handling such long trains, or whose cars are likely to be handled in such trains, they can ill afford to spend much money for the heavy repairs and maintenance of wooden freight cars of under 60,000 pounds capacity, and it is clearly no longer profitable to build such cars, which are necessarily too lightly framed to operate in conjunction with the heavy capacity steel car.

"As showing the conclusions arrived at, on one of the prominent railway systems of the country, the writer has before him the report and recommendations made to the chief executive officer of the company at a recent date. The report recommends the retiring of 4,600 coal and coke cars ranging from nine to twenty-three years in age, and having from 40,000 to 60,000 pounds capacity.

"It was shown that these cars average a cost of $95.98 per year for repairs, or 37.8 per cent. of the average total value of the cars. The tonnage of these cars being compared with tonnage of new steel cars which have been used by the company in large numbers, when considered in connection with the first cost and the cost of maintenance of steel cars, and based on experience, showed conclusively that the company could buy 3,000 new steel cars having a total capacity 20 per cent. greater than that of the 4,600 wooden cars, and out of the amount that it would cost to maintain the wooden cars for one year they could pay 6 per cent. interest on the cost price of the new steel cars and have remaining over $215,000. A desire for the greatest economy for the owners of the roads will assure the substitution of a lesser number of larger capacity steel cars for old light capacity wooden ones.

"Although steel underframing and practically all-steel construction has been used for a number of years for about all of the various types of freight equipment, yet it is only during the past three years that much has been done in this country to adapt such construction to the various styles of passenger equipment.

"Very satisfactory designs have been developed for baggage and postal cars, as well as for suburban and regular passenger service, and within the past year also for Pullman sleepers. It is yet too early to predict the outcome, but it seems to the writer that in future development of the design for steel passenger equipment cars there may be a happy medium arrived at, and generally adopted, where the underframes and the superstructure framing will be of metal, but a reasonable use be made of wood or some fireproof substitute, other than metal, which will permit of a decorative treatment that is more pleasing to the eye than is the case where thin metal is used, and which will also have all of the reasonable and necessary elements of safety for those who entrust their lives in such cars.

"In the early days of steel cars the matter of repairs was looked upon with many misgivings by the average master car builder and car repair foreman. Experience in handling these cars in large numbers has shown that there was no cause for any uneasiness on this score. In the repairs of steel cars it is not necessary to employ specially trained labor, and very few extra tools or facilities are absolutely necessary, though, of course, a

few especially adapted tools and appliances will greatly facilitate the work. On roads having large numbers of steel cars in service it has been found that not more than one-half of one per cent. of this equipment need be out of service at any one time, needing repairs, while in the case of wooden cars from two to four per cent. is not unusual."

Mr. G. R. Henderson, in discussing the paper, and referring particularly to the design of steel car mentioned, which carries all of the load on the center sill, said in part: "This must depend very largely upon the type of car. Where we have a car with sides eight feet high there is a great strength available to support the load. I think under conditions like that it would be manifestly unwise to design our cars so that the entire load is carried on the center sills.

"When you consider a hopper car with the deep bolster possible, you will see that there is no difficulty whatever in transferring the strain from the side sill to the center plate of the car. In other words, the design of the car should be made according to the service for which it is intended.

"I think that this Club should initiate some action toward unifying the construction of steel cars. I do not know of any better way than for this Club to suggest this subject to the Master Car Builders' Association committee as subjects for action at the meeting of the Association next summer.

"It is important that the standard sizes be amply strong. I would like to read the specifications for sills of fifty-ton steel hopper and flat cars which I prepared some time ago.

"For hoppers, the body is to be proportioned for carrying 125,000 pounds uniformly distributed between bolsters, in addition to the dead weight of the car.

"For flat cars the sills are to be proportioned for carrying 125,000 pounds uniformly distributed in addition to the dead weight and also for 75,000 pounds concentrated on a line across the car at any point between the bolsters, the side sills being considered as carrying the same proportion of load as the center sills, to allow for concentrated applications in loading heavy objects.

"In both types of cars the center sills and draft attachments must be proportioned for a force of 100,000 pounds pulling, and 200,000 pounds buffing and strains due to either or both the horizontal forces and the vertical loading combined must not exceed 12,000 pounds per square inch in tension (net section), or 12,000 — l/r in compression where l = the length and r = radius of gyration both in inches. The maximum rivet shear must not exceed 8,000 pounds per square inch, and the rivet bearing 16,000 pounds per square inch.

"I would merely call attention to the fact that some years ago there were wooden hoppers of thirty-ton capacity which, I think, weighed about 30,000 pounds. Now, if you take the present designs, you will find that they run about 40,000 pounds, so that with the one-third more weight per car we get two-thirds more carrying capacity. I think that is well worth the extra expense, when you take into consideration a great many other points in favor of the larger cars.

"In the early part of last year we obtained bids on steel cars and the prices ran a little less than three cents per pound. You can get very little structural steel erected for less than four cents a pound, and even at that price very few people would think of putting up a wooden building nowadays. In the long run the saving on the steel car is certainly very large and it seems to me that it is perfectly logical that the railroad companies should put up steel cars rather than to continue their old wooden cars on side tracks and hold them there for months for repairs."

Mr. W. R. McKeen, Jr., in a written discussion included some very interesting recommendations as follows:

"Personally I consider it a mistake to build any more wooden freight or passenger cars. Having decided to use steel for car structures it is a mistake to use the same methods and designs of framing and to maintain the general exterior and interior appearances of the wooden car.

"The design of steel car should be consistent with the material used, the idea being to obtain the maximum efficiency of the steel as a structural material. The character of material steel being so entirely different from that of wood, a great many advantages and possibilities are obtainable in a steel car design which were impossible with wooden cars. Because steel is used for cars, is no reason why there should be a material increase in weight; my opinion is that it should decrease the weight."

Suggestions for steel passenger car structures:

"Round roof, with its strength, economical features of weight and construction.

"Induced or mechanical ventilation obsoleting the gravity system; providing intake of fresh air at the floor of car; suction or exhaust ventilation at the top.

"All latterly disposed steel should be utilized for strengthening the car frame in resisting shock, including side sills, plates, steel side, braces, etc. Sufficient area of cross section provided in center sills for small or ordinary shocks.

"End construction such as to preclude the possibility of telescoping."

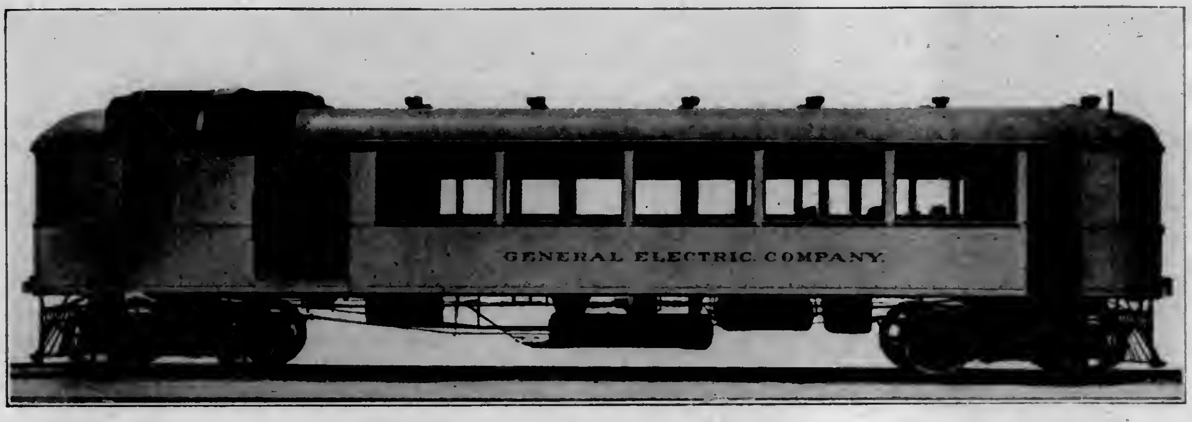
Change in British Patent Laws.—Consul-General Wynne, of London, in referring to the new British patent law, which goes into effect on January 1, 1908, quotes the following, which will be of direct interest to American machinery builders: If a patented article or process be manufactured or carried on exclusively or mainly outside the United Kingdom, then, unless the patentee prove that the patented article or process is manufactured or carried on to an adequate extent in the United Kingdom, or give satisfactory reasons why it is not so manufactured or carried on, the comptroller may make an order revoking the patent forthwith, or he may make an order revoking it after a specified interval if the patented article or process be not in the meantime adequately manufactured or carried on within the United Kingdom; but in the latter case, if the patentee give satisfactory reasons for the failure so to manufacture or carry on within the prescribed time, the comptroller may extend the period by not more than one year. To obtain such an order, application must be made to the comptroller at least four years from the date of the patent and one year from the passing of the act; moreover, any decision of the comptroller is to be subject to an appeal to the High Court, and no order is to be made that will be at variance with any treaty, convention, arrangement, or engagement with any foreign country or British possession.

ANNUAL COST OF POWER PER BRAKE HORSE-POWER.*

B. H. P. of Unit.	Steam.	Electricity.	Gas.	Gasoline.
1	$600.00	$312.50	$380.00	$487.50
2	500.00	282.00	312.50	416.00
3	437.50	252.00	260.00	350.00
4	375.00	227.50	220.00	300.00
5	320.00	207.50	192.50	262.50
6	280.00	192.00	172.50	240.00
7	250.00	179.00	160.00	210.00
8	230.00	168.00	152.50	182.50
9	210.00	158.00	145.00	165.00
10	195.00	152.00	140.00	152.00
12	175.00	140.00	132.50	137.50
14	165.00	133.00	126.00	122.00
16	157.50	128.00	120.00	112.50
18	150.00	126.00	116.50	107.50
20	146.00	123.00	113.00	102.00
22	140.00	121.50	110.00	98.00
24	137.50	119.50	107.50	95.00
26	133.00	117.50	105.00	92.50
28	130.00	116.50	102.50	90.00
30	127.50	115.00	102.00	87.50
35	124.00	113.50	100.00	85.00
40	120.00	112.00	98.00	82.50
50	112.50	110.00	96.00	80.00
60	105.00	108.00	94.00	78.00
70	100.00	106.00	92.00	76.00
80	95.00	104.00	90.00	74.00
90	90.50	102.00	88.00	72.00
100	86.40	100.00	86.00	70.00

* Unit costs: Coal, $5 per ton; electricity, $0.135 per K. W.-hour; gas, $1.20 per 1,000 cubic feet, at 760 B. T. U.; gasoline, $0.20 per gallon.

—*William O. Webber, in Engineering News.*



GASOLINE ELECTRIC RAILWAY MOTOR CAR.

GASOLINE-ELECTRIC MOTOR CAR FOR RAILWAY SERVICE.

The General Electric Company has been studying the problem of designing a satisfactory independently driven motor car for railway service for several years. After careful consideration and a study of all the cars in operation, it was decided that a car propelled by electric motors connected to the axles, the current being obtained from a generating plant aboard the car, was the most satisfactory and promising type of construction. This arrangement permits the greatest ease and flexibility in control of the speed and power of the car and eliminates many structural problems present with both the direct gasoline or steam driven type.

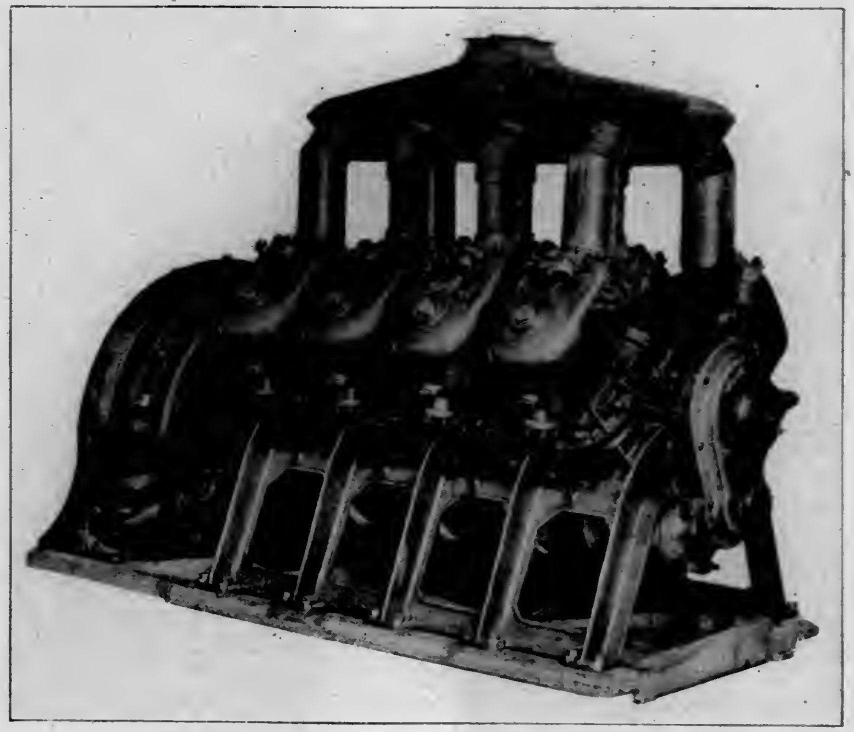
About two years ago this company finished a car which it had designed for service on the Delaware & Hudson Railway. This car was illustrated and described on page 88 of the March, 1906, issue of this journal. It resembled a standard passenger coach in appearance, was 65 ft. long, carried 40 passengers and weighed about 65 tons. It was mounted on specially designed trucks, which carried two ordinary railway motors, such as are in general use on the Interborough Railway in New York. The car contained a six-cylinder horizontal opposed gasoline engine of 160 brake horse-power, which was direct connected to a 120-k.w. General Electric generator designed for 600 volts.

This car was operated and thoroughly tested out and while it did not prove a commercial success it nevertheless served as a most valuable experiment in showing exactly where improvements should and could be made.

From the results of the operation of this car the General Electric Company has designed and built another car of the same general type, which is now in operation. This car measures 50 ft. in length, instead of 65, it will carry 44 passengers instead of 40 and weighs, fully equipped, but 31 tons as compared with 65 tons for the other car. The car body is built of steel throughout, with the exception of the interior finish, and a specially designed and much lighter type of truck has been used. An entirely new design of gasoline engine having eight cylinders, and weighing very much less than the English engine with six cylinders used in the other car, has been designed. The generator is also extremely light for its capacity and the resulting combination appears to be most satisfactory in every way. The car is capable of comparatively high speeds, having maintained on its test run a speed of 50 miles per hour on a level track and 47 miles per hour on a rising grade.

The car body is designed throughout with special reference to the service required, the main object in view being to secure a maximum carrying capacity with a minimum weight, while at the same time not neglecting the matter of structural strength and durability. The shape of the ends of the body has been made semi-circular and a plain oval shape roof is used which permits of great strength with minimum weight and greatly reduces the air resistance. The underframe consists of two 6-in. I-beams as center sills and 6-in. channels as side sills. These are braced diagonally to give stiffness and are further strengthened by a number of cross beams between the bolsters. Truss rods are fitted to each of the side sills. The superstructure of the car is built on T-irons bent in U-shape and forming, in one piece, the side posts and the carlines. The sheathing is of steel plate and the floors are of two layers of wood armored on the underside with steel plates. Ventilation is obtained by means of 12 suction ventilators along the roof.

The interior is divided into four compartments, the one at the forward end being the engine room, behind which is a small baggage compartment, then a smoking compartment and a main passenger compartment taking up a large part of the body. A small observation room is provided at the rear end and toilet facilities are included. The interior of the car, with the exception of the engine room, is finished in selected Mexican mahogany. The seats are upholstered in leather and individual electric lights, one at each seat, furnish the artificial light. Exceptionally good natural lighting is obtained by the very large double windows. There is no wood used in the engine compartment.



EIGHT CYLINDER GASOLINE ENGINE AND 90 K.W. GENERATOR.

The gasoline engine, which develops 100 brake horse-power at 550 r. p. m., is direct connected to a 90-k.w. direct current gen-

few especially adapted tools and appliances will greatly facilitate the work. On roads having large numbers of steel cars in service it has been found that not more than one-half of one per cent. of this equipment need be out of service at any one time, needing repairs, while in the case of wooden cars from two to four per cent. is not unusual."

Mr. G. R. Henderson, in discussing the paper, and referring particularly to the design of steel car mentioned, which carries all of the load on the center sill, said in part: "This must depend very largely upon the type of car. Where we have a car with sides eight feet high there is a great strength available to support the load. I think under conditions like that it would be manifestly unwise to design our cars so that the entire load is carried on the center sills.

"When you consider a hopper car with the deep bolster possible, you will see that there is no difficulty whatever in transferring the strain from the side sill to the center plate of the car. In other words, the design of the car should be made according to the service for which it is intended.

"I think that this Club should initiate some action toward unifying the construction of steel cars. I do not know of any better way than for this Club to suggest this subject to the Master Car Builders' Association committee as subjects for action at the meeting of the Association next summer.

"It is important that the standard sizes be amply strong. I would like to read the specifications for sills of fifty-ton steel hopper and flat cars which I prepared some time ago.

"For hoppers, the body is to be proportioned for carrying 125,000 pounds uniformly distributed between bolsters, in addition to the dead weight of the car.

"For flat cars the sills are to be proportioned for carrying 125,000 pounds uniformly distributed in addition to the dead weight and also for 75,000 pounds concentrated on a line across the car at any point between the bolsters, the side sills being considered as carrying the same proportion of load as the center sills, to allow for concentrated applications in loading heavy objects.

"In both types of cars the center sills and draft attachments must be proportioned for a force of 100,000 pounds pulling, and 200,000 pounds buffing and strains due to either or both the horizontal forces and the vertical loading combined must not exceed 12,000 pounds per square inch in tension (net section), or 12,000 — l/r in compression where l = the length and r = radius of gyration both in inches. The maximum rivet shear must not exceed 8,000 pounds per square inch, and the rivet bearing 16,000 pounds per square inch.

"I would merely call attention to the fact that some years ago there were wooden hoppers of thirty ton capacity which, I think, weighed about 30,000 pounds. Now, if you take the present designs, you will find that they run about 40,000 pounds, so that with the one third more weight per car we get two thirds more carrying capacity. I think that is well worth the extra expense, when you take into consideration a great many other points in favor of the larger cars.

"In the early part of last year we obtained bids on steel cars and the prices ran a little less than three cents per pound. You can get very little structural steel erected for less than four cents a pound, and even at that price very few people would think of putting up a wooden building nowadays. In the long run the saving in the steel car is certainly very large and it seems to me that it is perfectly logical that the railroad companies should put up steel cars rather than to continue their old wooden cars on side tracks and hold them there for months for repairs."

Mr. W. R. McKeen, Jr., in a written discussion included some very interesting recommendations as follows:

"Personally I consider it a mistake to build any more wooden freight or passenger cars. Having decided to use steel for car structures it is a mistake to use the same methods and designs of framing and to maintain the general exterior and interior appearances of the wooden car.

"The design of steel car should be consistent with the material used, the idea being to obtain the maximum efficiency of the steel as a structural material. The character of material steel being so entirely different from that of wood, a great many advantages and possibilities are obtainable in a steel car design which were impossible with wooden cars. Because steel is used for cars, is no reason why there should be a material increase in weight; my opinion is that it should decrease the weight."

Suggestions for steel passenger car structures:

"Round roof, with its strength, economical features of weight and construction.

"Induced or mechanical ventilation obsoleting the gravity system; providing intake of fresh air at the floor of car; suction or exhaust ventilation at the top.

"All latterly disposed steel should be utilized for strengthening the car frame in resisting shock, including side sills, plates, steel side, braces, etc. Sufficient area of cross section provided in center sills for small or ordinary shocks.

"End construction such as to preclude the possibility of telescoping."

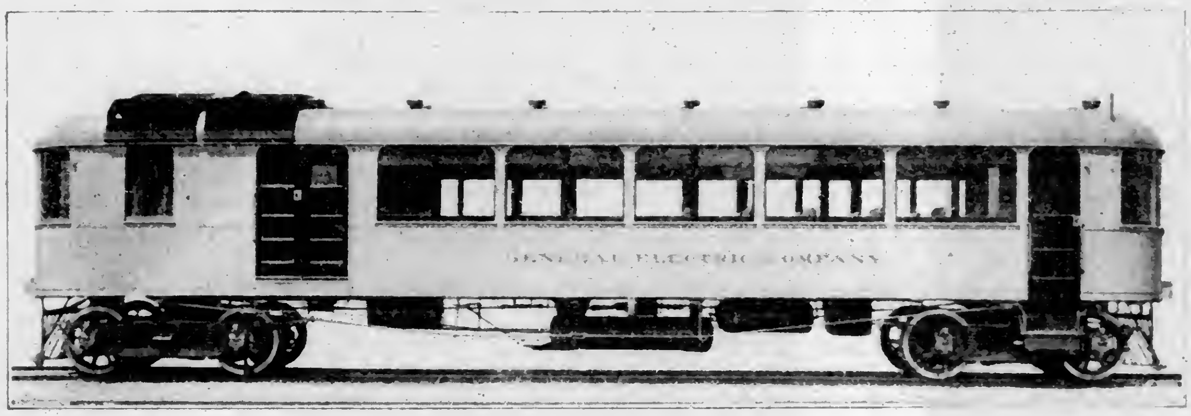
CHANGE IN BRITISH PATENT LAWS.—Consul-General Wynne, of London, in referring to the new British patent law, which goes into effect on January 1, 1908, quotes the following, which will be of direct interest to American machinery builders: If a patented article or process be manufactured or carried on exclusively or mainly outside the United Kingdom, then, unless the patentee prove that the patented article or process is manufactured or carried on to an adequate extent in the United Kingdom, or give satisfactory reasons why it is not so manufactured or carried on, the comptroller may make an order revoking the patent forthwith, or he may make an order revoking it after a specified interval if the patented article or process be not in the meantime adequately manufactured or carried on within the United Kingdom; but in the latter case, if the patentee give satisfactory reasons for the failure so to manufacture or carry on within the prescribed time, the comptroller may extend the period by not more than one year. To obtain such an order, application must be made to the comptroller at least four years from the date of the patent and one year from the passing of the act; moreover, any decision of the comptroller is to be subject to an appeal to the High Court, and no order is to be made that will be at variance with any treaty, convention, arrangement, or engagement with any foreign country or British possession.

ANNUAL COST OF POWER PER BRAKE HORSE-POWER.*

B. H. P. of Unit.	Steam.	Electricity.	Gas.	Gasoline.
1	$600.00	$312.50	$380.00	$487.50
2	500.00	282.00	312.50	416.00
3	437.50	252.00	260.00	350.00
4	375.00	227.50	220.00	300.00
5	320.00	207.50	192.50	262.50
6	280.00	192.00	172.50	240.00
7	250.00	179.00	160.00	210.00
8	230.00	168.00	152.50	182.50
9	210.00	158.00	145.00	165.00
10	195.00	152.00	140.00	152.00
12	175.00	140.00	132.50	137.50
14	165.00	133.00	126.00	122.00
16	157.50	128.00	120.00	112.50
18	150.00	126.00	116.50	107.50
20	140.00	123.00	113.00	102.00
22	140.00	121.50	110.00	98.00
24	137.50	119.50	107.50	95.00
26	133.00	117.50	105.00	92.50
28	130.00	116.50	102.50	90.00
30	127.50	115.00	102.00	87.50
35	124.00	113.50	100.00	85.00
40	120.00	112.00	98.00	82.50
50	112.50	110.00	96.00	80.00
60	105.00	108.00	94.00	78.00
70	100.00	106.00	92.00	76.00
80	95.00	104.00	90.00	74.00
90	90.50	102.00	88.00	72.00
100	89.40	100.00	86.00	70.00

* Unit costs: Coal, $5 per ton; electricity, $0.135 per K. W.-hour; gas, $1.20 per 1,000 cubic feet, at 760 B. T. U.; gasoline, $0.20 per gallon.

—*William O. Webber, in Engineering News.*



GASOLINE ELECTRIC RAILWAY MOTOR CAR.

GASOLINE-ELECTRIC MOTOR CAR FOR RAILWAY SERVICE.

The General Electric Company has been studying the problem of designing a satisfactory independently driven motor car for railway service for several years. After careful consideration and a study of all the cars in operation, it was decided that a car propelled by electric motors connected to the axles, the current being obtained from a generating plant aboard the car, was the most satisfactory and promising type of construction. This arrangement permits the greatest ease and flexibility in control of the speed and power of the car and eliminates many structural problems present with both the direct gasoline or steam driven type.

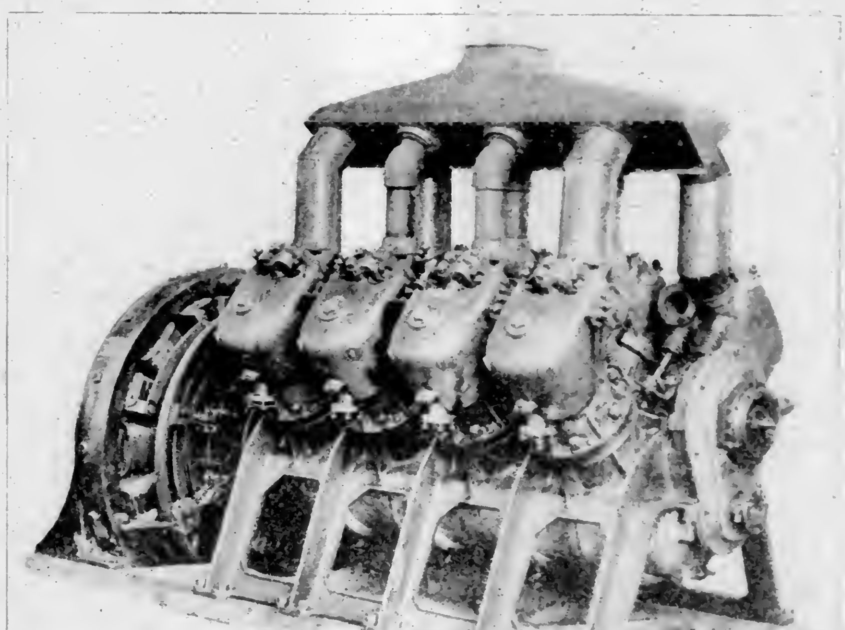
About two years ago this company finished a car which it had designed for service on the Delaware & Hudson Railway. This car was illustrated and described on page 88 of the March, 1906, issue of this journal. It resembled a standard passenger coach in appearance, was 65 ft. long, carried 40 passengers and weighed about 65 tons. It was mounted on specially designed trucks, which carried two ordinary railway motors, such as are in general use on the Interborough Railway in New York. The car contained a six-cylinder horizontal opposed gasoline engine of 160 brake horse-power, which was direct connected to a 120-k.w. General Electric generator designed for 600 volts.

This car was operated and thoroughly tested out and while it did not prove a commercial success it nevertheless served as a most valuable experiment in showing exactly where improvements should and could be made.

From the results of the operation of this car the General Electric Company has designed and built another car of the same general type, which is now in operation. This car measures 50 ft. in length, instead of 65, it will carry 44 passengers instead of 40 and weighs, fully equipped, but 31 tons as compared with 65 tons for the other car. The car body is built of steel throughout, with the exception of the interior finish, and a specially designed and much lighter type of truck has been used. An entirely new design of gasoline engine having eight cylinders and weighing very much less than the English engine with six cylinders used in the other car, has been designed. The generator is also extremely light for its capacity and the resulting combination appears to be most satisfactory in every way. The car is capable of comparatively high speeds, having maintained on its test run a speed of 50 miles per hour on a level track and 47 miles per hour on a rising grade.

The car body is designed throughout with special reference to the service required, the main object in view being to secure a maximum carrying capacity with a minimum weight, while at the same time not neglecting the [illegible] strength and durability. The shape of the ends of the body has been made semi-circular and a plain oval shape roof is used which permits of great strength with minimum weight and greatly reduces the air resistance. The underframe consists of two 6-in. I-beams as center sills and 6-in. channels as side sills. These are braced diagonally to give stiffness and are further strengthened by a number of cross beams between the bolsters. Truss rods are fitted to each of the side sills. The superstructure of the car is built on T irons bent in U-shape and forming, in one piece, the side posts and the carlines. The sheathing is of steel plate and the floors are of two layers of wood armored on the underside with steel plates. Ventilation is obtained by means of 12 suction ventilators along the roof.

The interior is divided into four compartments, the one at the forward end being the engine room, behind which is a small baggage compartment, then a smoking compartment and a main passenger compartment taking up a large part of the body. A small observation room is provided at the rear end and toilet facilities are included. The interior of the car, with the exception of the engine room, is finished in selected Mexican mahogany. The seats are upholstered in leather and individual electric lights, one at each seat, furnish the artificial light. Exceptionally good natural lighting is obtained by the very large double windows. There is no wood used in the engine compartment.



EIGHT-CYLINDER GASOLINE ENGINE AND 90 K.W. GENERATOR.

The gasoline engine, which develops 100 brake horse-power at 550 r. p. m., is direct connected to a 90-k.w. direct current gen

erator, which furnishes current at variable voltage. This current is fed to the motors through the medium of a control system, by means of which the voltage of the generator may be governed according to the requirements. Two motors are provided, each being rated at 60 h.p.

Engine.—The gasoline engine has eight cylinders, each of which is 8 in. in diameter, and has a stroke of 7 in. The cylinders are placed four on each side at 90 degs. to each other or an angle of 45 degs. with the vertical. Each cylinder casting is of very soft fine grained iron and is self-contained, including the water jacket. There is one admission and one exhaust valve for each cylinder, which are so arranged as to permit the inspection of both valves by the removal of 2 nuts. The connecting rods are chrome nickel steel and the crank shaft is a forging of 40-point carbon steel. It is a four-throw crank, having an angle of 180 degs., all of the crank pins being in the same plane. The two center cranks are on the same side of the shaft and the two outside cranks are set at 180 degs. with these. Two connecting rods, one from each cylinder, are connected to each crank pin. This arrangement of cranks and cylinders gives a most satisfactory system for balancing purposes, as well as a practically constant torque. Each cylinder is fastened to the engine base by six bolts, the base being made of one casting of Parsons' manganese bronze. The crank casing, which is made oil tight, is of aluminum.

All of the valves are actuated from one cam shaft, which is entirely enclosed in a circular tunnel running the entire length of the engine base and formed in the main casting.

There are two carburetters of the float feed type and the ignition is high tension, a separate coil being provided for each cylinder. The cooling system operates on the thermo-syphon principle, the radiator being situated on the roof of the car. The total cooling surface amounts to about 1,300 sq. ft. The water jackets are connected to the radiator by means of pipes running vertically from the engine and the circuit is completed by means of other pipes leading from the radiator to the cylinder jackets. This forms the most simple system of cooling arrangement possible as it entirely eliminates the necessity of using pumps or cooling fans.

Considerable difficulty has been experienced in starting gasoline engines of this size and the same principle that proved so satisfactory in starting the engine in the former car has been used in this case. This consists of a special breech block mechanism fitted into the top of one of the cylinders, which fires a black powder cartridge and gives an impulse for starting the engine. This piece of mechanism is illustrated in one of the photographs and can be put into any cylinder desired, being left in place while the engine is being operated.

The gasoline is stored in a large steel tank of 90 gallons capacity, suspended beneath the floor of the car. The supply is raised by means of a diaphragm pump to a small auxiliary tank in the cab, being filtered in transit. It is fed to the carburetter from this tank by gravity. Forced lubrication is used, there being a nest of pumps operated from the main shaft. All of the oil used for lubricating purposes flows to the crank case from which it can be drained and filtered.

Generator.—The generator is a G. E. 90-k.w. eight-pole separately excited unit, which has been specially designed with the view of obtaining the lightest possible machine for the output and at the same time keeping the temperature rise within a reasonable figure. It is provided with commutating poles, which in connection with the potential type of control gives a great flexibility. The advantage of this arrangement is readily appreciated when it is considered that at starting the field excitation is weak and large currents are required to give the necessary starting torque to the motors. The normal voltage of the generator is 250 volts, at which time the current is 360 amperes, but at starting a current of 800 amperes can be secured at a corresponding decrease in voltage. It would be impossible to commutate so large a current in a machine of so great a k.w. capacity per pound without the use of commutating poles. The total weight of the generator, including the exciter, is only 2,740 lbs. while a standard machine of this output weighs 8,800 lbs. While the temperature rise is higher and the efficiency lower in this generator than in standard apparatus these conditions have been fully considered in the design. The efficiency, however, proves to be 88 per cent., or only 3 per cent. lower than the standard machine.

The exciter is a 3-k.w. 70-volt shunt wound generator with its armature mounted directly on the armature shaft of the main generator and its field yoke supported by the bearing brackets, enabling it to fit under the back end of the generator armature windings.

Control System.—The speed of the motors on the trucks is governed by potential control. Since the generator is separately excited the voltage delivered can be varied by means of rheostats connected in series with the exciting current. The master controller, which is arranged to give seven steps with the motors connected in series and eight steps with them connected in parallel, has four handles, three of which are mounted one above the other on concentric shafts. The function of the top handle is to advance and retard the ignition of the engine; the second handle controls the throttle of the engine and the third handle controls the rheostat in the exciting current and hence the voltage of the generator and the speed of the motors and also gives the change in motor connections from series to parallel. The fourth handle operates the reversing switch.

A storage battery is provided for supplying the lighting circuits and normally floats upon the exciting circuit. Its charging and discharging is controlled by means of a reverse current relay which permits the lights being supplied directly from the exciting circuit or the storage battery, according to the voltage of the circuit.

BREECH BLOCK MECHANISM FOR FIRING BLACK POWDER CARTRIDGE.

The car is heated by passing part of the exhaust gases through pipes located in the car body. The brakes are of the straight air type, the compressor being direct connected to the engine.

The trucks are of the swing bolster type with 36-in. wheels, there being one motor mounted on each truck. These were designed and constructed by the American Locomotive Company.

The car body, which was built by the Wason Manufacturing Co., of Springfield, Mass., has the following general dimensions:

Length over all	50 ft.
Length of engine room	9 ft. 6 in.
Length of passenger compartment	26 ft. 5 in.
Width	8 ft. 8 in.
Height over all	12 ft. 10½ in.
Seating capacity	44

SIGNAL TESTS.—A series of 197 surprise tests of signals on the Lehigh Valley Railroad has just been completed and it is reported that every one was obeyed exactly. The entire main line of this road is fully equipped with automatic signals.

CO-EFFICIENTS OF FRICTION BETWEEN WHEELS AND RAILS.*

By George L. Fowler.

The resistance of a wheel to slipping on the rail depends upon two causes frequently confused, but which are to be considered separately. These are friction and abrasion.

Frictional resistance is due to the roughness of the two surfaces in contact, and may be compared to the lifting of the weight to be moved over the successive inequalities of the surface on which it rests. Abrasion, on the other hand, involves the removal or cutting away of the particles of the masses in contact. The slipping of a wheel, such as would produce a flat spot, involves both frictional resistance and abrasion. If there were no slipping of the wheel on the rail there would be no wear, provided the rolling action did not produce sufficient pressure on any one point to crush the metal or cause it to flow. But there is always more or less slip even on a straight line.

There are two kinds of slipping to which car wheels may be subjected. One is the skidding action due to the locking of the wheels by the brake-shoes. The other form occurs when the driving wheels of electric motor cars, for instance, are turned faster than the corresponding rate of motion of the car and the whole periphery of the wheel slides over the rail. In order to determine whether the resistances to these two kinds of slipping were the same, certain experiments were made.

The apparatus was designed to produce, as nearly as possible, the actual conditions of track work.

Two pieces of steel rails of 75 lbs. section, one of which had been worn smooth in service; the other, a piece of new rail, together with a section of a steel wheel and a section of a cast-iron wheel, with the treads of both smooth and free from imperfections, were used for the tests. The testing machines were made by Tinius Olsen & Company, one with a capacity of 100,000 lbs. and the other a capacity of 50,000 lbs.

The apparatus is shown in the accompanying illustrations for the skidding movement. The wheel section was set on the rail and loaded by the 100,000 lbs. capacity machine. It was then slipped over the rail by a pull on the connection rod reaching to the other machine which measured the amount of the pull required to slip the wheel on the rail.

In loading the wheel, the pressure was applied through a plate resting on two rollers. In this way the friction, except that between the wheel and the rail, was reduced to practically nothing.

For the spinning motion, the bearing plate above the rollers was made convex and the bottom plate resting on the top of the wheel was made concave; both surfaces being concentric with the tread of the wheel. A pull on the wheel, therefore, caused it to roll under the bearing plate as though it were revolving on its own center. The arrangement of this is clearly shown in the diagram.

The force required to move the wheel on the rail was weighed by a bell crank with a knife edge bearing, resting on a heavy casting attached to the bed plate of the small testing machine. The vertical arm was attached to the pull rod and the end of the horizontal arm had a bearing on a wedge or knife edge that was forced down by the platen of the machine.

The wheel section was placed in position on the rail and weighted with a predetermined load. Pressure was then applied to the wedge on the small machine. This pressure was transferred through the bell crank as a pull on the connecting rod. When slipping occurred, the event was marked instantly by the drop of the beam of the small machine. The movement of the wheel over the rail usually amounted to about 1-32 in. As the object of the investigation was to determine the friction at rest no attempt was made to measure the pull after the first slip occurred. This was markedly less than that required to start the movement from a state of rest.

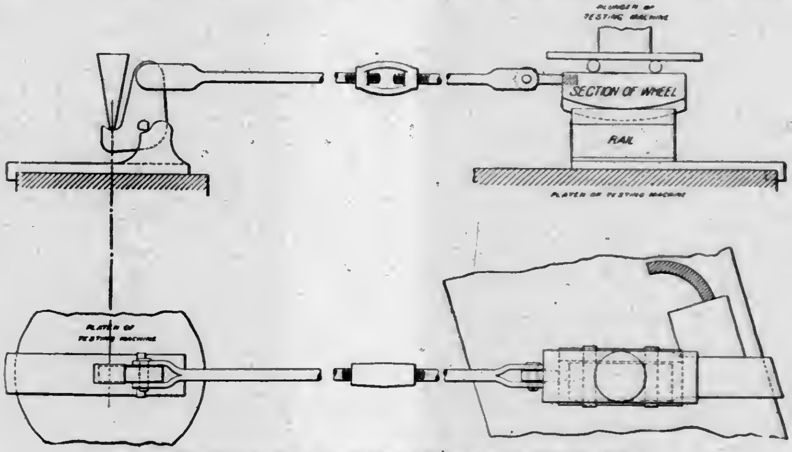
* Reprinted by special permission from "The Car Wheel," copyrighted by the Schoen Steel Wheel Company.

Separate tests were made with steel and cast-iron wheels on the old and new rails, for both the skidding and spinning motions. In loading the wheels, the weights were increased by regular increments of 2,000 lbs. up to 30,000 lbs. Three tests were made with each loading and for each condition of wheel movement. The average of the three tests in each case is given in the accompanying table.

There was so little difference in the pull required to slip the wheels on the old and new rails that an average of the results obtained is given as the resistance to spinning and skidding of the two wheels on a steel rail.

Load on Wheel in Lbs.	Kind of Motion.			
	Spinning.		Skidding.	
	Steel Wheel.	Cast Iron Wheel.	Steel Wheel.	Cast Iron Wheel.
2,000 lbs........	.259	.243	.285	.267
4,000 "	.240	.215	.254	.259
6,000 "	.234	.208	.245	.254
8,000 "	.228	.206	.246	.242
10,000 "	.215	.204	.238	.233
12,000 "	.212	.205	.237	.223
14,000 "	.207	.199	.233	.226
16,000 "	.204	.196	.232	.219
18,000 "	.204	.198	.231	.219
20,000 "	.201	.194	.236	.220
22,000 "	.205	.191	.238	.223
24,000 "	.204	.192	.235	.224
26,000 "	.205	.189	.232	.223
28,000 "	.203	.186	.236	.217
30,000 "	.203	.183	.234	.214

The table shows that the resistance to spinning of the steel wheel is somewhat greater than that of the cast-iron wheel, a fact



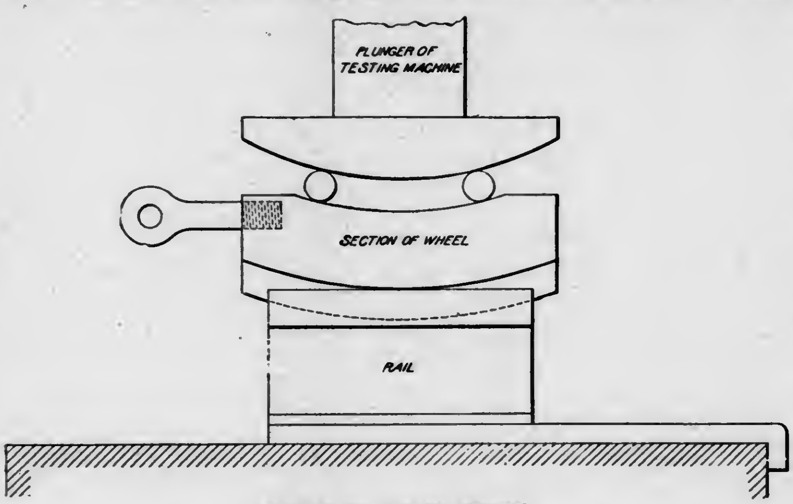
APPARATUS FOR TESTING SKIDDING RESISTANCE.

which is brought out quite forcibly by the coefficients of friction, in which the coefficient of the steel wheel is invariably higher than that of the cast-iron.

It also appears from this table, that the coefficient of friction of the steel wheel decreases as the load is increased, up to a pressure of about 15,000 lbs., after which it is practically constant. The coefficient of friction of the cast-iron wheel decreases rather rapidly, like that of the steel wheel, up to a load of 15,000 lbs., after which it falls away slowly, though a tendency to decrease with the increase of load is manifest.

As regards skidding, the values of the coefficients of the two wheels bear the same relation to each other as they do for spinning. The coefficient of resistance is greater for the steel wheel than for the cast-iron wheel; and there is the same falling off in the value of the coefficient as the load is increased up to about 15,000 lbs., after which that of the steel wheel is nearly constant, while that of the cast-iron wheel continues to fall away slowly. It would be difficult to explain these phenomena without the data obtained in the investigations previously described, made to determine the area of contact between the wheel and the rail, and the relative rate of abrasion of the steel and cast-iron wheels on the emery wheel. The results of those investigations also serve to explain why the coefficient for a skidding wheel is higher than the coefficient for a wheel that is spinning.

In the case of the cast-iron wheel, it was shown in the preceding chapter that the imposition of a heavy load caused a breaking down of the metal in the rail at a certain point, while no such failure occurred with the steel wheel under the same load. The cast-iron wheel being rigid, inelastic and incompressible on the tread, was forced down into the metal of the rail, causing the rail to do all of the yielding needed to produce the area of contact obtained; with the result that it was soon compressed beyond its elastic limit and given a permanent set. The steel wheel yielded as well as the rail, thus relieving the rail of a part of its compression and increasing the area of contact. This behavior of the two wheels explains, in part, the results obtained in these tests. In addition, it must be remembered that the normal coefficient of friction is greater between steel and steel, than it is between cast-iron and steel.



APPARATUS FOR TESTING SPINNING RESISTANCE.

When the cast-iron wheel is loaded on the rail, it indents the rail in proportion to the pressure applied, without being distorted itself. If, then, it is turned, as by a motor, it simply revolves in the concave depression in the rail, without undergoing any deformation itself and with no resistance other than that of overcoming the friction between the surfaces of the wheel and rail. The steel wheel, on the other hand, is itself compressed, as well as the rail, so that when it is turned a continuous progressive compression of the tread is set up, equal to the amount of the original compression. Hence, the resistance to turning will be equal to the frictional resistance plus that set up by this compression.

It was shown that the cast-iron wheel was cut away much more rapidly under the emery wheel than were the steel tires and wheels. In the tests for skidding, the loads were successively applied without readjusting the wheel on the rail, with the result that the steel wheel was skidded about 1¼ in. and the cast-iron wheel about 1 in. This was done under loads increasing from 2,000 lbs. up to 30,000 lbs. Under this treatment, the steel wheel developed a slid-flat spot about 9-16 in. long, and the cast-iron wheel a spot about 7-8 in. long. In both cases the rail was spotted and the metal was rolled up in folds, indicating the direction of the motion of the wheel. The piece of rail used with the steel wheel was spotted for a distance of about 1¾ in., while the piece used with the cast-iron wheel was spotted for a length of about 1½ in. This abrasion of the cast-iron wheel probably accounts for the lower resistance to skidding as compared with the steel wheel. For the same weight and for the same distance of skidding, the amount of metal abraded from the cast-iron wheel was in almost exactly the same ratio to that removed from the steel wheel, as is shown in the diagram of abrasion tests.

It will be remembered that, for the lower wheel loads, the investigation of contact areas showed that there was comparatively little difference between the areas obtained with cast-iron wheels and with steel wheels, and that it was inferred that the total compression of the metal was approximately the same in both cases. Under these circumstances it would be expected that, if the power required to distort the metal of a steel rail and tire were the same, the resistance to skidding of the steel wheel and the cast-iron wheel would also be the same. But, owing to the more rapid abrasion of the cast-iron wheel, as soon as it begins to skid it wears, and, by thus increasing the area of contact, it lessens the depression of the rail, decreases the amount of metal to be distorted, lowers the resistance to the motion, and makes the coefficient of friction of skidding less on the cast-iron wheel than on the steel wheel.

This depression of the rail, due to the imposition of the wheel load, accounts for the higher coefficient of friction obtained with a skidding wheel than with a spinning wheel. With a wheel spinning, there is no continuous deformation of the metal of the rail to be affected. In skidding, there is a depression of the rail to be carried forward like a wave, which naturally raises the resistance and makes the coefficient greater than where slipping over one spot alone takes place.

While it is not safe to draw rigid conclusions from the limited amount of data obtained, it does appear that inasmuch as the steel wheel offers greater resistance to spinning it is better adapted for use as the driving wheel of an electric car than the cast-iron wheel; and further, its higher coefficient of friction renders it less liable to skidding.

This matter of wheels skidding, with the consequent development of flat spots on the tread, was considered of enough importance to warrant further investigation.

It has been noted by many other investigators that steel wheels do not flatten as readily as cast-iron wheels. By some this is attributed to the fact that small flat spots, once formed on the tread of a steel wheel may be rolled out, whereas they have a tendency to grow larger on cast-iron wheels. The abrasion and skidding tests which have been made seem to show, however, that it is the lower resistance to grinding of the cast-iron wheel that accounts for the more rapid development of these flat spots.

To briefly recapitulate, these tests showed that the rate of grinding of the first ⅛ in. below the tread was about 4.64 times as fast in the cast-iron wheel as in the Schoen steel wheel. For the second ⅛ in. the ratio became 6.37, and for the third ⅛ in., 15.93, showing the rapid decrease of wearing resistance of the cast-iron wheel below the surface. In the skidding tests in the laboratory, the effects were confined to the metal close to the surface, and it was found that, with the same amount of skidding, the amount of metal removed was about 5.12 times as great on the cast-iron wheel as on the steel wheel. A further check on these figures was afterwards obtained by taking the time required to remove approximately the same amount of material from the treads of cast-iron and steel wheels in a wheel grinding machine. It was found that it took from four to five times as long to grind down the steel wheels as it did to grind the cast-iron wheels. In all of the foregoing investigations, the metal of the wheel under test was kept cool, either by a stream of water or by doing the work so slowly that natural radiation counteracted the tendency to heat and the temperature of the metal was not raised above 100 deg. Fahr.

For the purpose of ascertaining whether the results of these investigations were comparable with the results obtained in actual railroad service, when the wheels were locked and skidded under a car, series of tests were made by skidding the wheels under a loaded car.

Through the courtesy of the New York, Ontario & Western a piece of track and a suitable box car were supplied for the tests. One pair of wheels and axle were removed from under the car, and replaced by an axle on which a Schoen steel wheel and a new cast-iron wheel had been pressed. These wheels were 33¼ in. and 33 in. in diameter, respectively. This pair of wheels were placed at the end of the car, and was fitted with two brake-beams, so that twice the usual brake-shoe pressure could be applied on the wheels. By this means, the wheels could be held in a fixed position throughout a run. But it was more difficult to hold the wheels at low speed than at high speed.

The car was loaded until the weight on the pair of wheels to be tested was exactly 24,000 lbs. The car was then hauled back and forth over a piece of track 1,850 ft. long. The brake was set and the wheels skidded for the whole distance. The car was hauled at two speeds, namely, 3 and 12 miles an hour.

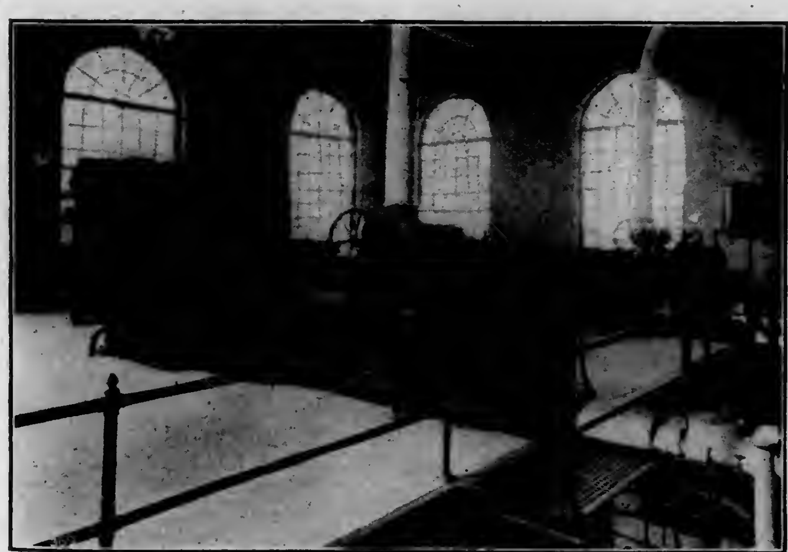
When the car was hauled at a speed of 3 miles an hour, flat spots were made on the steel wheel in area about .30 in., while the spots formed on the cast-iron wheel were in area .80 in. These areas correspond to diameters of about 5/8 in. and 1 in., respectively, though the spots on the cast-iron wheel were elongated to about 1 1/8 in., which indicated somewhat more metal removed. The volume of metal abraded from the cast-iron wheel was about 5 3/4 times greater than that from the steel wheel.

While the movement was slow the wheels remained cool. But when the speed was increased to 12 miles an hour, heating took place and the cutting was more rapid on the steel wheel.

For the first 1,850 ft. run the areas of the flat spots produced at a speed of 12 miles an hour averaged 8.125 sq. in. on the steel wheel and 4.445 sq. in. on the cast-iron wheel. The estimated amount of metal worn away was 4.63 times as much with the steel wheel as with the cast-iron wheel.

When the skidding was continued the rate of wear increased very rapidly with the cast-iron wheel, while there was little increase with the steel wheel. At the end of the run of 3,700 ft., the area of the flat spot on the steel wheel was 8.43 sq. in., an increase of .305 sq. in., while the area of the spot on the cast-iron wheel was 5.72 sq. in., an increase of 1.275 sq. in. From this it appears that the cast-iron wheel wore away more rapidly than the steel wheel after the hard surface metal had been broken through.

The indications are that in skidding a short distance at low speed a cast-iron wheel is more apt to develop a flat spot than is a steel wheel. On the other hand, if the skidding continues for some distance at a high speed, the wheel becomes heated and then the steel wheel is the first to yield, unless the surface chill of the cast-iron wheel has already been worn through.



POWER PLANT FOR ELECTRIC DRIVEN PUMPING STATION.

The United States Reclamation Service, a bureau under the Department of the Interior, is doing a large amount of work in connection with the irrigation of the large arid districts in the west, and is converting enormous tracts of formerly worthless land into highly productive farms. Among these varied projects is one in the vicinity of Garden City, Kansas, known as the Garden City Project, which is now about to be put into operation. The Arkansas River, which flows through this section of the country, carries, in the wet season, a large body of water, but during the dry season its bed is practically dry. There is, however, in all seasons a considerable body of water flowing a short distance below the surface of the ground and this project consists of a central electric generating station and twenty-three separate electric-driven pumping stations located along the line of flow of the underground water, which makes it available for irrigation purposes during the dry weather.

The area affected is a strip of land, about 10,000 acres, extending for about twenty miles northeast of the river. It consists of a canal running through the strip from which the various irrigation ditches are led. This canal, which is known as the "farmer's ditch," is connected to the Arkansas River, and during the period of high water is fed from that source, a flood gate being provided to control the supply. During the dry season, however, the canal is fed by the pumping stations.

The power plant which furnishes the electric current for operating all of these stations is of the most efficient and modern type and a very high economy of operation has been secured. In the boiler room there are two 200 h.p. Sterling boilers generating steam at 160 lbs. pressure with 120 degrees superheat. Draft is obtained by a steel stack 150 ft. high. In the engine room there are two turbo generators of 225 k.w. capacity, each generating three-phase 60-cycle current at 6600 volts. The exciter is direct connected to the shaft of each of the generators. The turbines are fitted with an automatic system for filtering and supplying their own lubricating oil. The current is controlled by oil switches located in the basement, which are mechanically operated from a switchboard of five panels placed in the engine room.

The power plant is a brick and steel structure located adjacent to the line of the Santa Fé Railroad near Deerfield, Kansas. The coal supply is brought in by the railroad, a siding being provided for storing the cars. The current is carried on overhead lines to the different pumping stations.

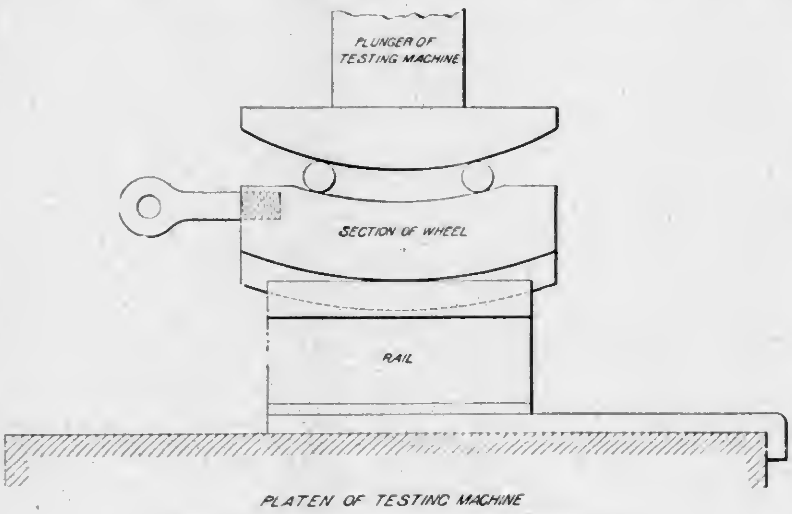
The D'Oiler Engineering Company, of Philadelphia, were the engineers and contractors for the entire power generating plant.

TESTING PLANT FOR ELECTRIC CARS.—There has been installed in the electrical laboratories of the Worcester Polytechnic Institute a testing plant for heavy electric street and interurban cars. The plant, in general, consists of four pairs of supporting wheels mounted in pedestals, which are adjustable along the base and can be arranged to suit any car. The shafts of these wheels are extended for the purpose of attaching fly wheels, whose weights are adjustable, which serve the purpose of imitating the starting inertia of the car on test. The train grade and curve resistance, which is usually obtained by absorption brakes, is in this case obtained by connecting electric generators to each shaft. The four generators are of the same type and size and have their fields connected in series. The exciting current is obtained from a direct current machine with adjustable field rheostat. The current in the field may thus be varied, as desired, by changing the voltage of the exciting generator. The armatures of the four generators are connected in parallel to the load resistance. The generators are connected to the shafts by a pinion and gear, the usual suspension bearings being used. Although a traction dynamometer for registering the drawbar pull has not yet been installed, it is expected that eventually such an instrument will be put into place.

TRAVELING ENGINEERS' ASSOCIATION.—The committee on subjects desires all members to submit subjects for consideration at the next annual meeting, which will be of general interest to the locomotive department and of benefit to the association. Any subject submitted will be given careful consideration by the committee, of which Mr. W. G. Wallace, 1600 Commercial National Bank Building, Chicago, is the chairman.

ELECTRICAL NIGHT AT THE NEW YORK RAILROAD CLUB.—The March meeting of the New York Railroad Club will be given up to the annual electrical night, at which short papers by a number of authorities on electrification of steam railways will be read.

In the case of the cast-iron wheel, it was shown in the preceding chapter that the imposition of a heavy load caused a breaking down of the metal in the rail at a certain point, while no such failure occurred with the steel wheel under the same load. The cast-iron wheel being rigid, inelastic and incompressible on the tread, was forced down into the metal of the rail, causing the rail to do all of the yielding needed to produce the area of contact obtained; with the result that it was soon compressed beyond its elastic limit and given a permanent set. The steel wheel yielded as well as the rail, thus relieving the rail of a part of its compression and increasing the area of contact. This behavior of the two wheels explains, in part, the results obtained in these tests. In addition, it must be remembered that the normal coefficient of friction is greater between steel and steel, than it is between cast-iron and steel.



APPARATUS FOR TESTING SPINNING RESISTANCE.

When the cast-iron wheel is loaded on the rail, it indents the rail in proportion to the pressure applied, without being distorted itself. If, then, it is turned, as by a motor, it simply revolves in the concave depression in the rail, without undergoing any deformation itself, and with no resistance other than that of overcoming the friction between the surfaces of the wheel and rail. The steel wheel, on the other hand, is itself compressed, as well as the rail, so that when it is turned a continuous progressive compression of the tread is set up, equal to the amount of the original compression. Hence, the resistance to turning will be equal to the frictional resistance plus that set up by this compression.

It was shown that the cast-iron wheel was cut away much more rapidly under the emery wheel than were the steel tires and wheels. In the tests for skidding, the loads were successively applied without readjusting the wheel on the rail, with the result that the steel wheel was skidded about 1¼ in. and the cast-iron wheel about 1 in. This was done under loads increasing from 2,000 lbs. up to 30,000 lbs. Under this treatment, the steel wheel developed a slid flat spot about 9/16 in. long, and the cast-iron wheel a spot about 7/8 in. long. In both cases the rail was spotted and the metal was rolled up in folds, indicating the direction of the motion of the wheel. The piece of rail used with the steel wheel was spotted for a distance of about 1¾ in., while the piece used with the cast-iron wheel was spotted for a length of about 1½ in. This abrasion of the cast-iron wheel probably accounts for the lower resistance to skidding as compared with the steel wheel. For the same weight and for the same distance of skidding, the amount of metal abraded from the cast-iron wheel was in almost exactly the same ratio to that removed from the steel wheel, as is shown in the diagram of abrasion tests.

It will be remembered that, for the lower wheel loads, the investigation of contact areas showed that there was comparatively little difference between the areas obtained with cast-iron wheels and with steel wheels, and that it was inferred that the total compression of the metal was approximately the same in both cases. Under these circumstances it would be expected that, if the power required to distort the metal of a steel rail and tire were the same, the resistance to skidding of the steel wheel and the cast-iron wheel would also be the same. But, owing to the more rapid abrasion of the cast-iron wheel, as soon as it begins to skid it wears, and, by thus increasing the area of contact, it lessens the depression of the rail, decreases the amount of metal to be distorted, lowers the resistance to the motion, and makes the coefficient of friction of skidding less on the cast-iron wheel than on the steel wheel.

This depression of the rail, due to the imposition of the wheel load, accounts for the higher coefficient of friction obtained with a skidding wheel than with a spinning wheel. With a wheel spinning, there is no continuous deformation of the metal of the rail to be affected. In skidding, there is a depression of the rail to be carried forward like a wave, which naturally raises the resistance and makes the coefficient greater than where slipping over one spot alone takes place.

While it is not safe to draw rigid conclusions from the limited amount of data obtained, it does appear that inasmuch as the steel wheel offers greater resistance to spinning it is better adapted for use as the driving wheel of an electric car than the cast-iron wheel; and further, its higher coefficient of friction renders it less liable to skidding.

This matter of wheels skidding, with the consequent development of flat spots on the tread, was considered of enough importance to warrant further investigation.

It has been noted by many other investigators that steel wheels do not flatten as readily as cast-iron wheels. By some this is attributed to the fact that small flat spots, once formed on the tread of a steel wheel may be rolled out, whereas they have a tendency to grow larger on cast-iron wheels. The abrasion and skidding tests which have been made seem to show, however, that it is the lower resistance to grinding of the cast-iron wheel that accounts for the more rapid development of these flat spots.

To briefly recapitulate, these tests showed that the rate of grinding of the first ⅛ in. below the tread was about 4.64 times as fast in the cast-iron wheel as in the Schoen steel wheel. For the second ⅛ in. the ratio became 6.37, and for the third ⅛ in., 15.03, showing the rapid decrease of wearing resistance of the cast-iron wheel below the surface. In the skidding tests in the laboratory, the effects were confined to the metal close to the surface, and it was found that, with the same amount of skidding, the amount of metal removed was about 5.12 times as great on the cast-iron wheel as on the steel wheel. A further check on these figures was afterwards obtained by taking the time required to remove approximately the same amount of material from the treads of cast-iron and steel wheels in a wheel grinding machine. It was found that it took from four to five times as long to grind down the steel wheels as it did to grind the cast-iron wheels. In all of the foregoing investigations, the metal of the wheel under test was kept cool, either by a stream of water or by doing the work so slowly that natural radiation counteracted the tendency to heat and the temperature of the metal was not raised above 100 deg. Fahr.

For the purpose of ascertaining whether the results of these investigations were comparable with the results obtained in actual railroad service, when the wheels were locked and skidded under a car, series of tests were made by skidding the wheels under a loaded car.

Through the courtesy of the New York, Ontario & Western a piece of track and a suitable box car were supplied for the tests. One pair of wheels and axle were removed from under the car, and replaced by an axle on which a Schoen steel wheel and a new cast-iron wheel had been pressed. These wheels were 33¼ in. and 33 in. in diameter, respectively. This pair of wheels were placed at the end of the car, and was fitted with two brake-beams, so that twice the usual brake-shoe pressure could be applied on the wheels. By this means, the wheels could be held in a fixed position throughout a run. But it was more difficult to hold the wheels at low speed than at high speed.

The car was loaded until the weight on the pair of wheels to be tested was exactly 24,000 lbs. The car was then hauled back and forth over a piece of track 1,850 ft. long. The brake was set and the wheels skidded for the whole distance. The car was hauled at two speeds, namely, 3 and 12 miles an hour.

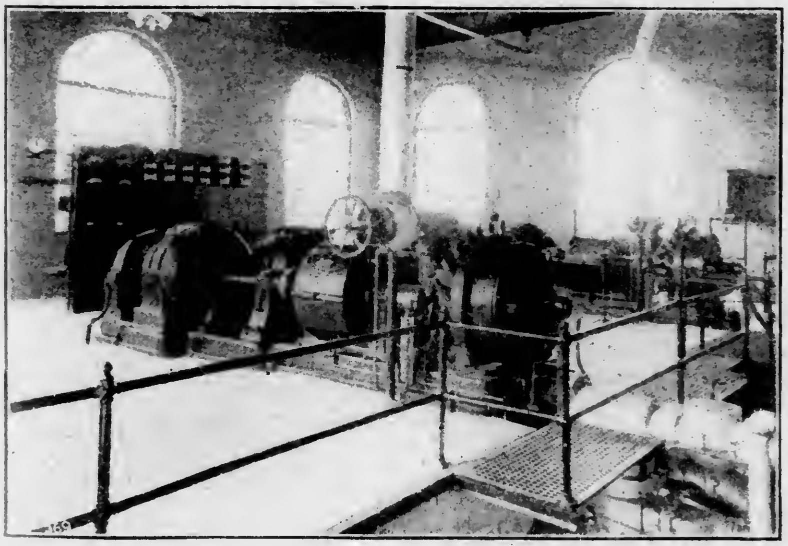
When the car was hauled at a speed of 3 miles an hour, flat spots were made on the steel wheel in area about .30 in., while the spots formed on the cast-iron wheel were in area .80 in. These areas correspond to diameters of about 5/8 in. and 1 in., respectively, though the spots on the cast-iron wheel were elongated to about 1 1/8 in., which indicated somewhat more metal removed. The volume of metal abraded from the cast-iron wheel was about 5¾ times greater than that from the steel wheel.

While the movement was slow the wheels remained cool. But when the speed was increased to 12 miles an hour, heating took place and the cutting was more rapid on the steel wheel.

For the first 1,850 ft. run the areas of the flat spots produced at a speed of 12 miles an hour averaged 8.125 sq. in. on the steel wheel and 4.445 sq. in. on the cast-iron wheel. The estimated amount of metal worn away was 4.63 times as much with the steel wheel as with the cast-iron wheel.

When the skidding was continued the rate of wear increased very rapidly with the cast-iron wheel, while there was little increase with the steel wheel. At the end of the run of 3,700 ft., the area of the flat spot on the steel wheel was 8.43 sq. in., an increase of .305 sq. in., while the area of the spot on the cast-iron wheel was 5.72 sq. in., an increase of 1.275 sq. in. From this it appears that the cast-iron wheel wore away more rapidly than the steel wheel after the hard surface metal had been broken through.

The indications are that in skidding a short distance at low speed a cast-iron wheel is more apt to develop a flat spot than is a steel wheel. On the other hand, if the skidding continues for some distance at a high speed, the wheel becomes heated and then the steel wheel is the first to yield, unless the surface chill of the cast-iron wheel has already been worn through.



POWER PLANT FOR ELECTRIC DRIVEN PUMPING STATION.

The United States Reclamation Service, a bureau under the Department of the Interior, is doing a large amount of work in connection with the irrigation of the large arid districts in the west, and is converting enormous tracts of formerly worthless land into highly productive farms. Among these varied projects is one in the vicinity of Garden City, Kansas, known as the Garden City Project, which is now about to be put into operation. The Arkansas River, which flows through this section of the country, carries, in the wet season, a large body of water, but during the dry season its bed is practically dry. There is, however, in all seasons a considerable body of water flowing a short distance below the surface of the ground and this project consists of a central electric generating station and twenty-three separate electric-driven pumping stations located along the line of flow of the underground water, which makes it available for irrigation purposes during the dry weather.

The area affected is a strip of land, about 10,000 acres, extending for about twenty miles northeast of the river. It consists of a canal running through the strip from which the various irrigation ditches are led. This canal, which is known as the "farmer's ditch," is connected to the Arkansas River, and during the period of high water is fed from that source, a flood gate being provided to control the supply. During the dry season, however, the canal is fed by the pumping stations.

The power plant which furnishes the electric current for operating all of these stations is of the most efficient and modern type and a very high economy of operation has been secured. In the boiler room there are two 200 h.p. Sterling boilers generating steam at 160 lbs. pressure with 120 degrees superheat. Draft is obtained by a steel stack 150 ft. high. In the engine room there are two turbo generators of 225 k.w. capacity, each generating three-phase 60-cycle current at 6000 volts. The exciter is direct connected to the shaft of each of the generators. The turbines are fitted with an automatic system for filtering and supplying their own lubricating oil. The current is controlled by oil switches located in the basement, which are mechanically operated from a switchboard of five panels placed in the engine room.

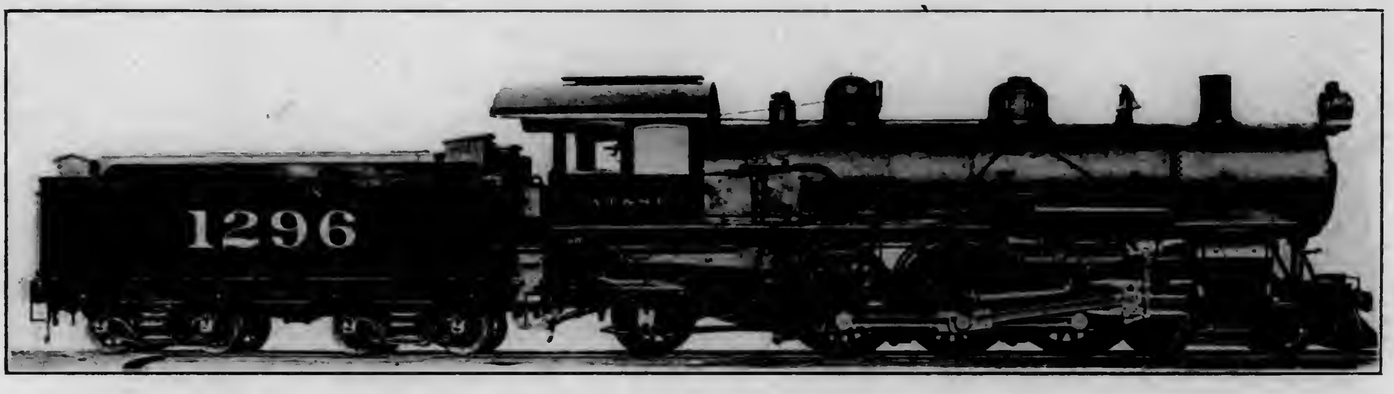
The power plant is a brick and steel structure located adjacent to the line of the Santa Fe Railroad near Deerfield, Kansas. The coal supply is brought in by the railroad, a siding being provided for storing the cars. The current is carried on overhead lines to the different pumping stations.

The D'Oiler Engineering Company, of Philadelphia, were the engineers and contractors for the entire power generating plant.

TESTING PLANT FOR ELECTRIC CARS.—There has been installed in the electrical laboratories of the Worcester Polytechnic Institute a testing plant for heavy electric street and interurban cars. The plant, in general, consists of four pairs of supporting wheels mounted in pedestals, which are adjustable along the base and can be arranged to suit any car. The shafts of these wheels are extended for the purpose of attaching fly wheels, whose weights are adjustable, which serve the purpose of imitating the starting inertia of the car on test. The train grade and curve resistance, which is usually obtained by absorption brakes, is in this case obtained by connecting electric generators to each shaft. The four generators are of the same type and size and have their fields connected in series. The exciting current is obtained from a direct current machine with adjustable field rheostat. The current in the field may thus be varied, as desired, by changing the voltage of the exciting generator. The armatures of the four generators are connected in parallel to the load resistance. The generators are connected to the shafts by a pinion and gear, the usual suspension bearings being used. Although a traction dynamometer for registering the drawbar pull has not yet been installed, it is expected that eventually such an instrument will be put into place.

TRAVELING ENGINEERS' ASSOCIATION.—The committee on subjects desires all members to submit subjects for consideration at the next annual meeting, which will be of general interest to the locomotive department and of benefit to the association. Any subject submitted will be given careful consideration by the committee, of which Mr. W. G. Wallace, 1600 Commercial National Bank Building, Chicago, is the chairman.

ELECTRICAL NIGHT AT THE NEW YORK RAILROAD CLUB.—The March meeting of the New York Railroad Club will be given up to the annual electrical night, at which short papers by a number of authorities on electrification of steam railways will be read.



PACIFIC TYPE LOCOMOTIVE WITH BALDWIN SUPERHEATER—A. T. & S. F. RY.

LOCOMOTIVES WITH LOW BOILER PRESSURE AND SMOKEBOX SUPERHEATERS.

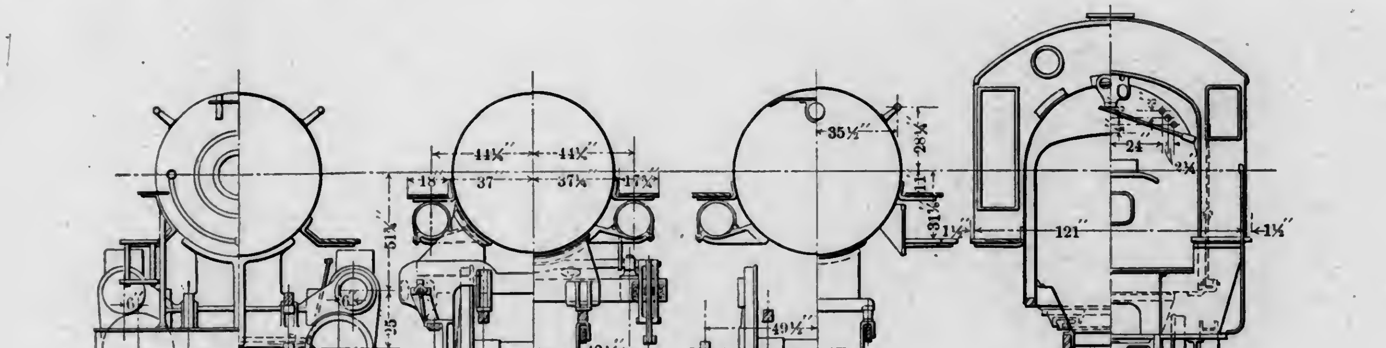
ATCHISON, TOPEKA & SANTA FE RAILWAY.

The Baldwin Locomotive Works has recently completed an order of 49 locomotives for the Atchison, Topeka & Santa Fe Ry., of which seven are of the Pacific type and 42 of the consolidation type. Ten of the latter are equipped for burning coal and all of the remainder are arranged for burning oil. These locomotives carry a boiler pressure of but 160 lbs. and are fitted with very large simple cylinders, so as to take advantage of the full adhesive weight with this low boiler pressure. The difficulty from condensation, which would be greatly increased because of the large increase in the area of the walls in these cylinders, has been reduced by the installation of smokebox superheaters in all of the locomotives. The superheaters are of the Baldwin type and are not intended or expected to deliver highly superheated steam but simply to give sufficient superheat to overcome the excessive condensation.

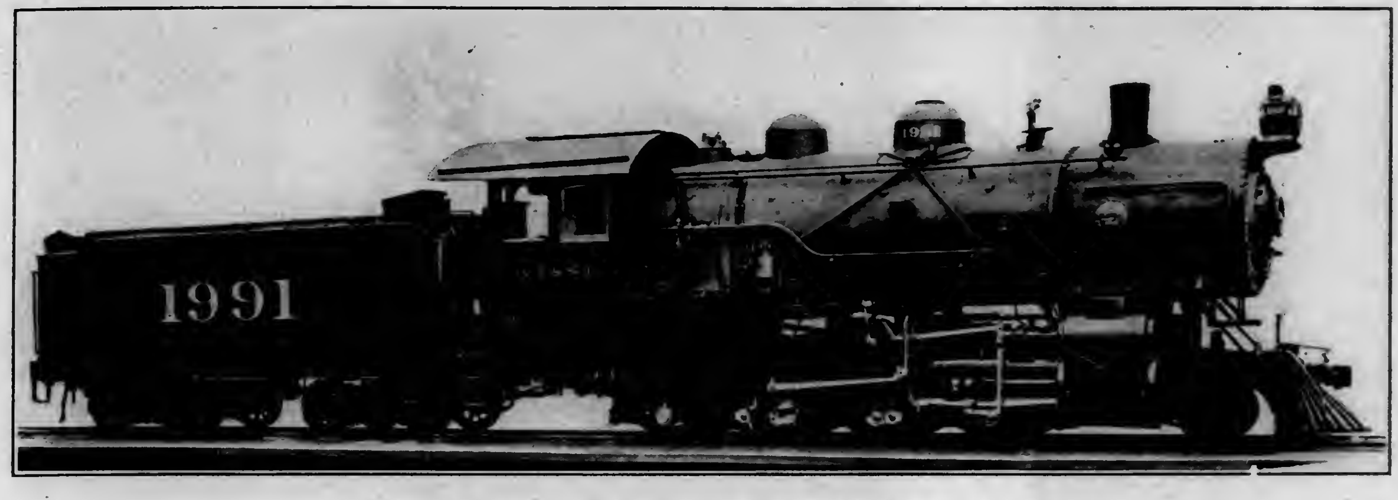
The Santa Fe has for some time been operating a ten-coupled locomotive with a superheater of this design and using a low boiler pressure with results which have been so satisfactory as to lead to the same arrangement on this large order of both freight and passenger engines. The principle advantage gained by this arrangement is the reduction in boiler troubles and ease of maintaining full pressure, especially in bad water districts where great difficulty has been found in keeping boilers tight.

Pacific Type Locomotives.—The seven passenger locomotives have 25x28 in. cylinders; 73 in. drivers and give a tractive effort of 32,600 lbs. They weigh nearly 233,000 lbs., of which 140,400 lbs. is on drivers, giving an average weight per driving axle of 46,800 lbs. This gives a factor of adhesion of 4.33 and a ratio of total weight to tractive effort of 7.12.

The boiler is of the straight type, 72 in. in diameter at the front ring. It contains 273-2-¼ in. tubes 20 ft. long, which give a heating surface of 3,202 sq. ft., or practically the same amount that will be found on a similar weight locomotive carrying 200 lbs. boiler pressure. The ratios of heating surface and grate area to cylinder volume, however, are naturally considerably



ELEVATIONS AND SECTIONS OF PACIFIC TYPE LOCOMOTIVE—A. T. & S. F. RY.



CONSOLIDATION LOCOMOTIVE WITH BALDWIN SUPERHEATER—A. T. & S. F. RY.

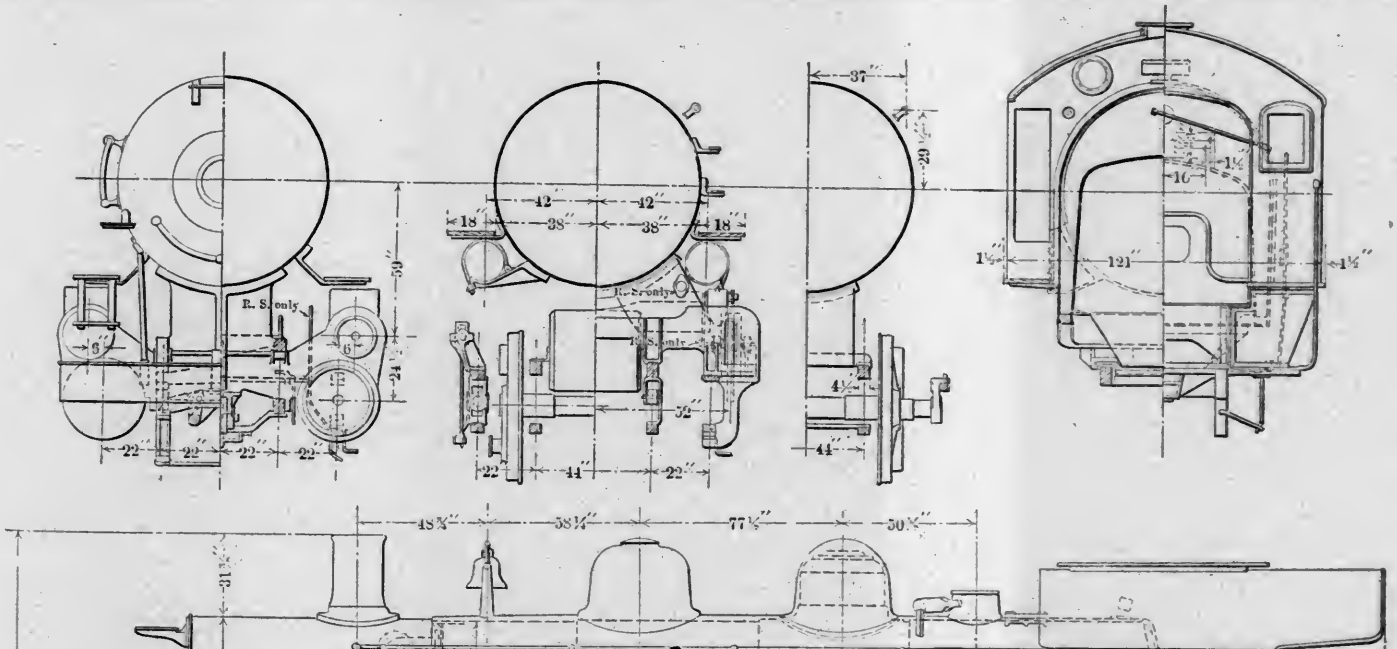
smaller than would be the case with the engine having higher pressure and smaller cylinders. The boiler barrel is built up of four rings having "diamond" butt jointed seams on the top center line.

The superheater is the same in general design as the one shown on page 89 of the March, 1907, issue of this journal, but differs from it in having the saturated steam enter the superheater at the front end and work backward, the final outlet being at the end nearest the front tube sheet, or at the point where the hottest gases are found. It has a heating surface of 709 sq. ft., giving 1 sq. ft. of superheating surface to about 4.5 sq. ft. of boiler heating surface.

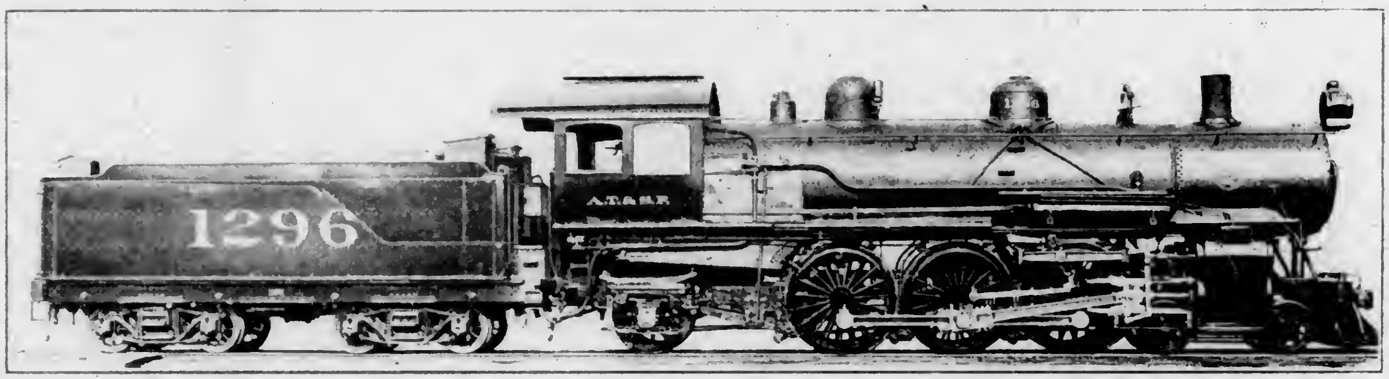
The cylinders are designed for the Walschaert valve gear and have valve chambers set 6 in. outside of the center line of the cylinders, so as to place the valve motion in practically one vertical plane. The arrangement of the valve gear is clearly shown in the general elevation and follows the most recent practice in design for Pacific type locomotives by having the link hung from cast steel supports located outside of the drivers and parallel to the engine frame, being carried by the guide yoke at the front and a suitable cross bearer at the rear. Outside of the link bearers, the details of this gear are practically the same as those for the consolidation locomotive, which are illustrated herewith and will be mentioned later.

The front truck is of the swing bolster type with cast steel saddle and 3-point suspension links. The rear truck is of the Rushton pattern with outside journals.

Consolidation Locomotives.—These locomotives have 24 x 32



ELEVATIONS AND SECTIONS OF CONSOLIDATION TYPE LOCOMOTIVE—A. T. & S. F. RY.



PACIFIC TYPE LOCOMOTIVE WITH BALDWIN SUPERHEATER—A. T. & S. F. RY.

LOCOMOTIVES WITH LOW BOILER PRESSURE AND SMOKEBOX SUPERHEATERS.

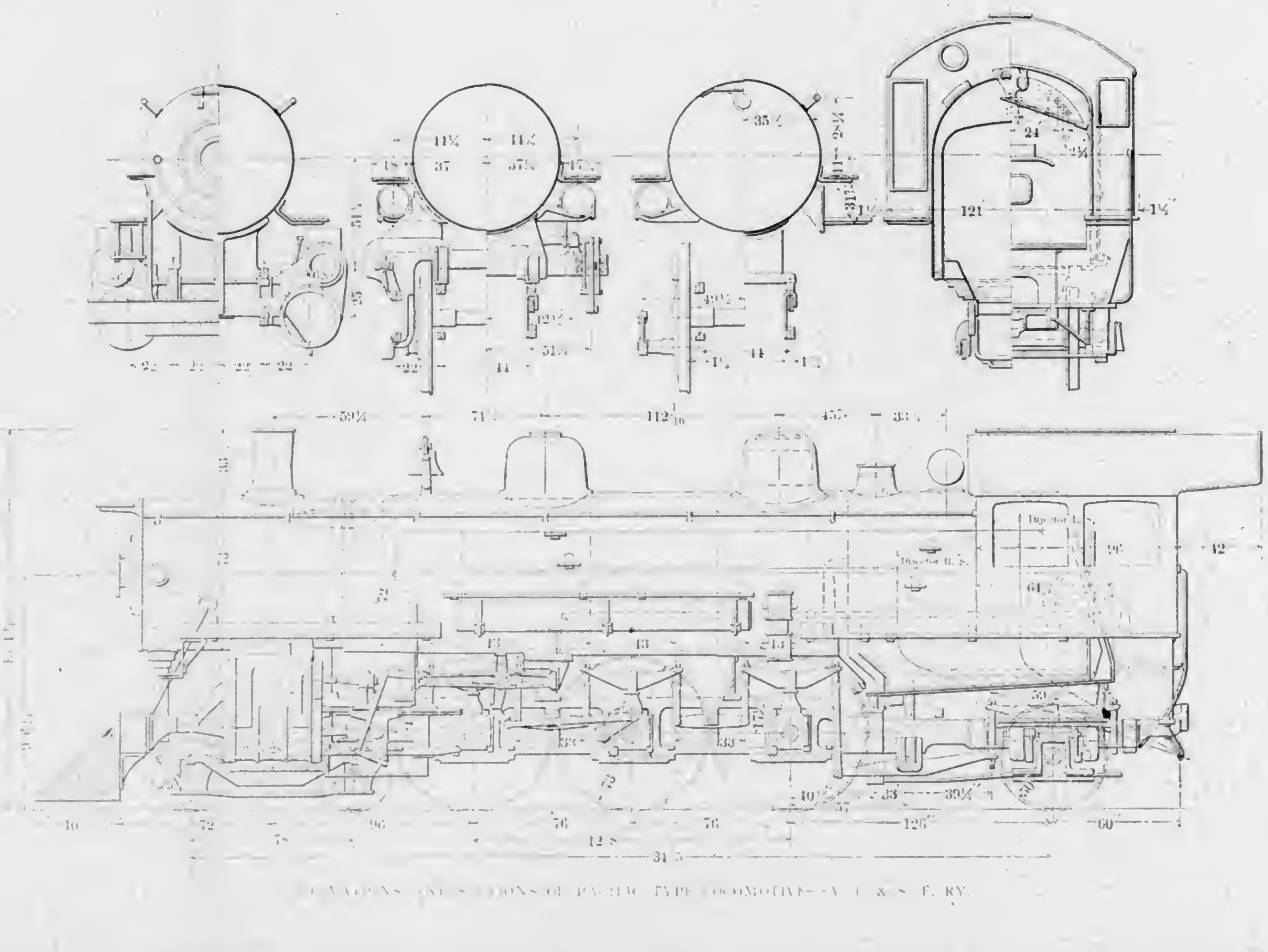
ATCHISON, TOPEKA & SANTA FE RAILWAY.

The Baldwin Locomotive Works has recently completed an order of 49 locomotives for the Atchison, Topeka & Santa Fe Ry., of which seven are of the Pacific type and 42 of the consolidation type. Ten of the latter are equipped for burning coal and all of the remainder are arranged for burning oil. These locomotives carry a boiler pressure of but 160 lbs. and are fitted with very large simple cylinders, so as to take advantage of the full adhesive weight with this low boiler pressure. The difficulty from condensation, which would be greatly increased because of the large increase in the area of the walls in these cylinders, has been reduced by the installation of smokebox superheaters in all of the locomotives. The superheaters are of the Baldwin type and are not intended or expected to deliver highly superheated steam but simply to give sufficient superheat to overcome the excessive condensation.

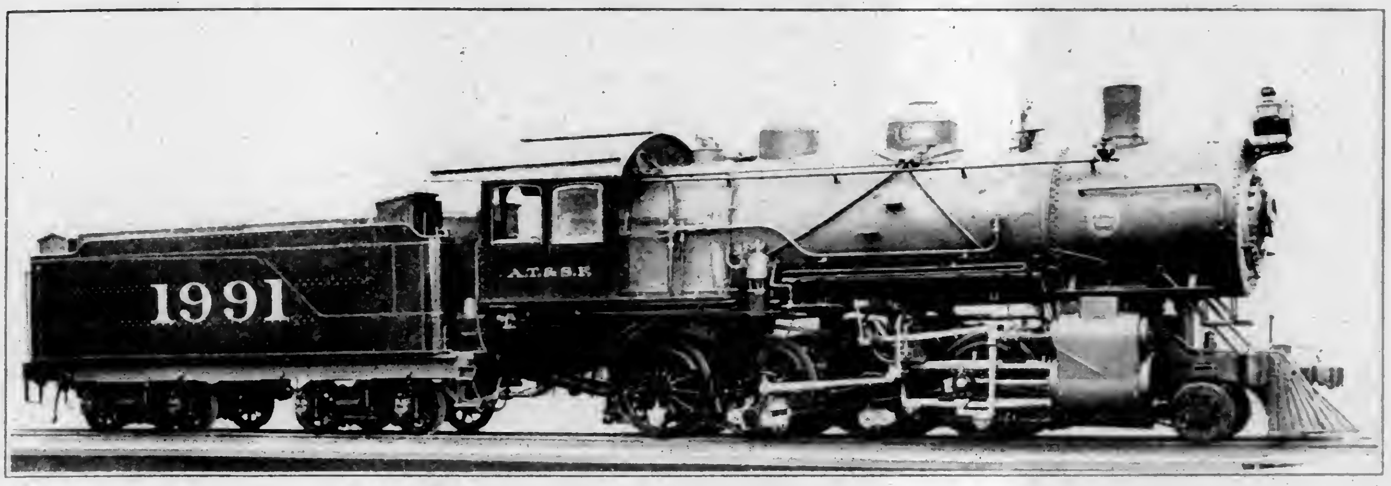
The Santa Fe has for some time been operating a ten-coupled locomotive with a superheater of this design and using a low boiler pressure with results which have been so satisfactory as to lead to the same arrangement on this large order of both freight and passenger engines. The principle advantage gained by this arrangement is the reduction in boiler troubles and ease of maintaining full pressure, especially in bad water districts where great difficulty has been found in keeping boilers tight.

Pacific Type Locomotives.—The seven passenger locomotives have 25x28 in. cylinders; 73 in. drivers and give a tractive effort of 32,000 lbs. They weigh nearly 233,000 lbs., of which 140,400 lbs. is on drivers, giving an average weight per driving axle of 46,800 lbs. This gives a factor of adhesion of 4.33 and a ratio of total weight to tractive effort of 7.12.

The boiler is of the straight type, 72 in. in diameter at the front ring. It contains 273-2¼ in. tubes 20 ft. long, which give a heating surface of 3,202 sq. ft., or practically the same amount that will be found on a similar weight locomotive carrying 200 lbs. boiler pressure. The ratios of heating surface and grate area to cylinder volume, however, are naturally considerably



ELEVATIONS AND SECTIONS OF PACIFIC TYPE LOCOMOTIVE—A. T. & S. F. RY.



CONSOLIDATION LOCOMOTIVE WITH BALDWIN SUPERHEATER — A. T. & S. F. RY.

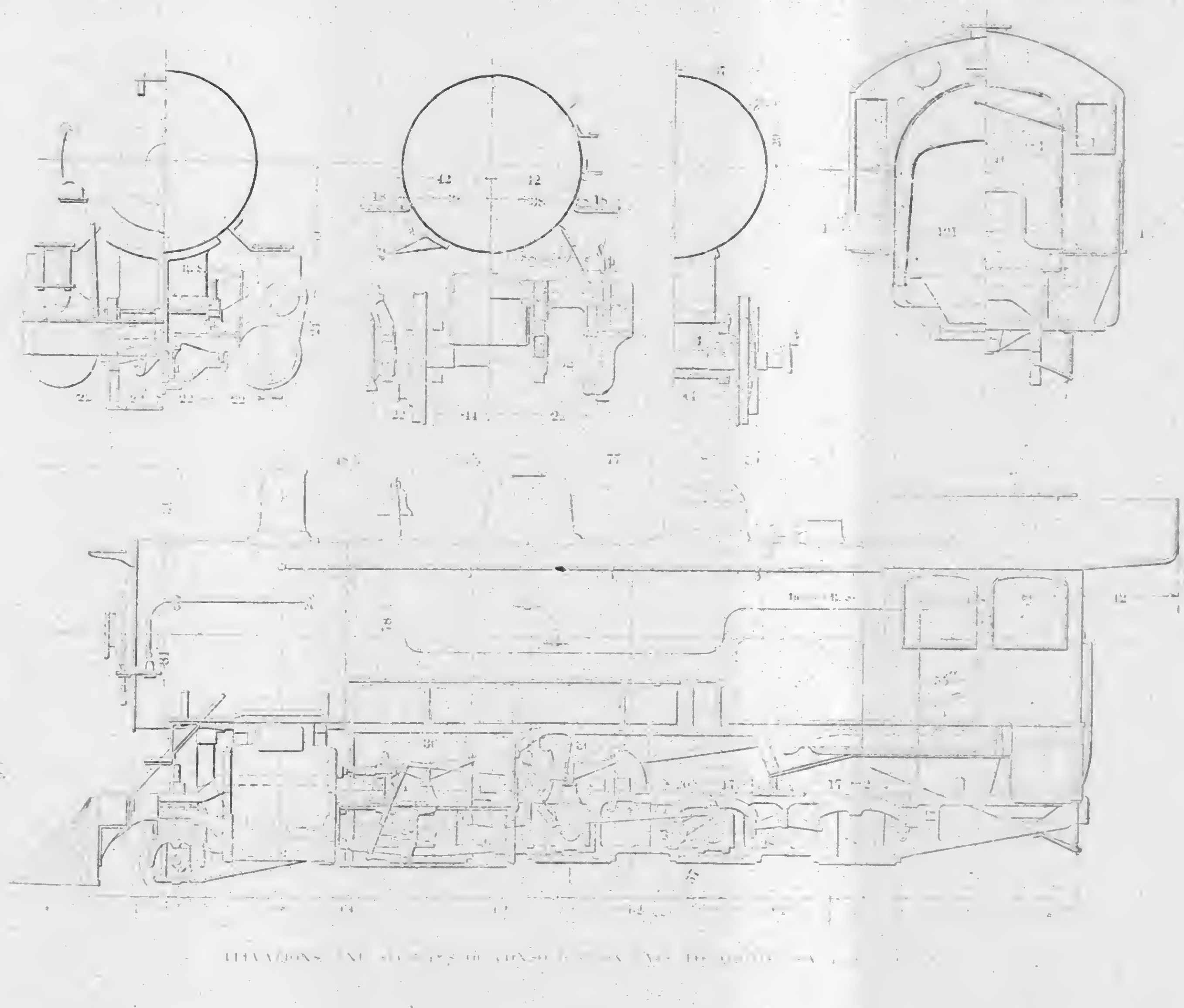
smaller than would be the case with the engine having higher pressure and smaller cylinders. The boiler barrel is built up of four rings having "diamond" butt jointed seams on the top center line.

The superheater is the same in general design as the one shown on page 89 of the March, 1907, issue of this journal, but differs from it in having the saturated steam enter the superheater at the front end and work backward, the final outlet being at the end nearest the front tube sheet, or at the point where the hottest gases are found. It has a heating surface of 700 sq. ft., being 1 sq. ft. of superheating surface to about 4.5 sq. ft. of water heating surface.

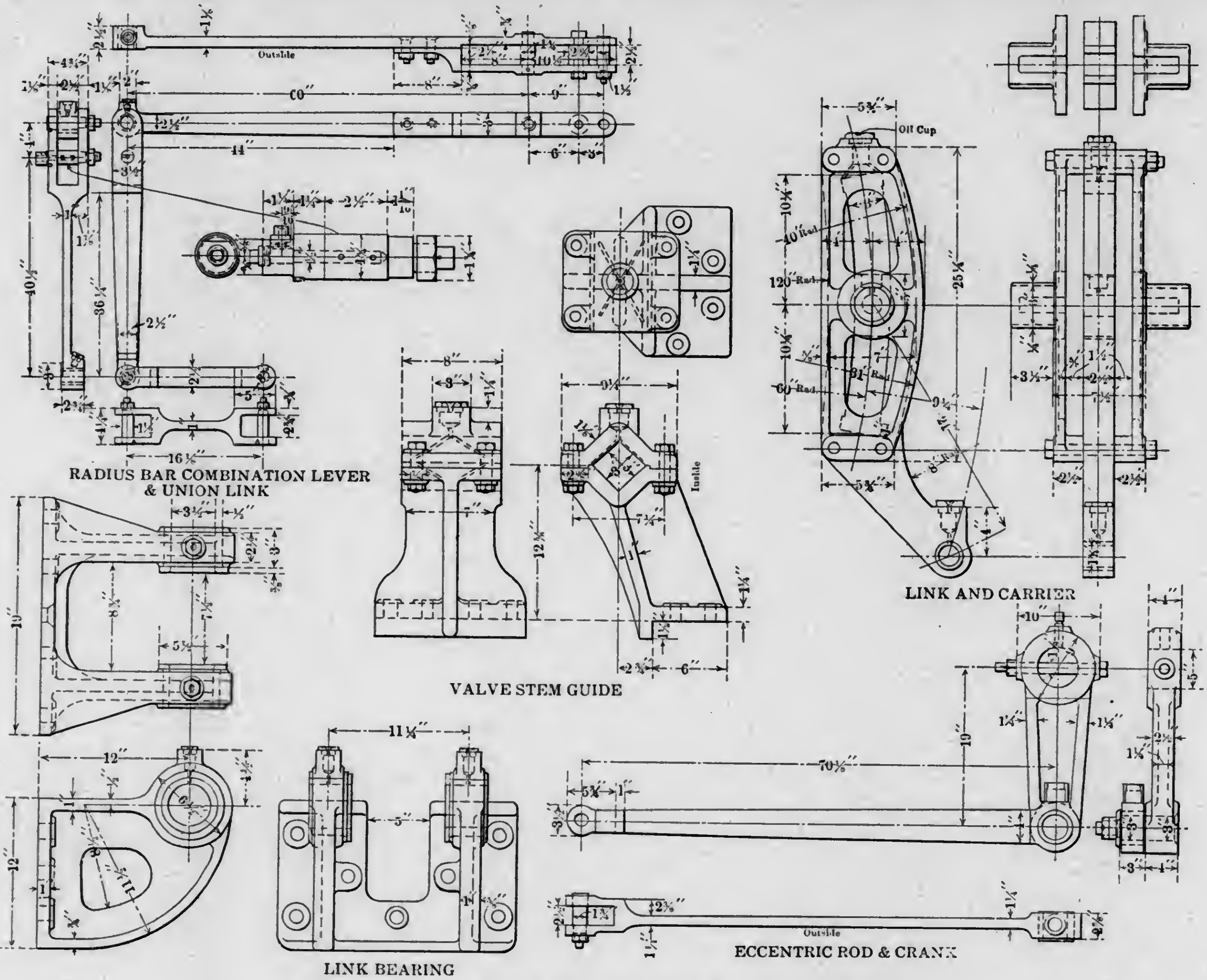
The cylinders are designed for the Walschaert valve gear and have valve chambers set 6 in. outside of the center line of the cylinders, so as to place the valve motion in practically one vertical plane. The arrangement of the gear is clearly shown in the general elevation and follows the most approved practice in design for Pacific type locomotives. The link is hung from cast steel supports located outside of the drivers and parallel to the engine frame, being secured by the guide yoke at the front and a suitable cross brace at the rear. Outside of the link bearers, the details of the gear are practically the same as those for the consolidation locomotive, which are illustrated herewith and will be mentioned later.

The front truck is of the swing bolster type with cast steel saddle and 3-point suspension links. The rear truck is of the Rushton pattern with outside journals.

Consolidation Locomotive. — These locomotives have 22 x 32 [illegible]



ELEVATIONS AND SECTIONS OF CONSOLIDATION LOCOMOTIVE [illegible]



DETAILS OF WALSCHAERT VALVE GEAR ON PACIFIC TYPE LOCOMOTIVE.

in. simple cylinders, 57 in. driving wheels and a tractive effort of 43,970 lbs. The boiler is also of the straight top design: measures 78¾ in. outside diameter at the front end. It contains 355 2-in. tubes, 15 ft. long, giving a total heating surface of 2,930 sq. ft. The boiler ratios and ratios of boiler to weights are about the average for this type of locomotive. The superheater is of the same design as used in the Pacific type engines and has 600 sq. ft. of heating surface, which is a ratio of 1 to 4.87 with the boiler heating surface.

The Walschaert valve gear design as applied to these locomotives is an excellent example of probably the simplest arrangement of this type of gear. It is all located in practically one vertical plane, and there is but one reversing shaft, and as few separate parts as can conveniently be used to fulfil the requirements. The link bearing and reverse shaft bearing are bolted to the wrought iron guide yoke which is given a good depth outside of the frames and is secured to them by a very large cast steel knee having ample bearing on the frame and for the full depth of the guide yoke. The top guides are also secured to the yoke by a cast steel knee. The link bearing, which has been designed with a view of obtaining the greatest rigidity with the least weight, is shown in the illustration, as is also the link itself, which is of wrought iron in one piece and is secured between two cast steel carriers having trunnions resting in the brass bushings of the link bearings.

The valve stem is keyed to a case hardened square sectioned extension, which rests in a cast steel guide secured to the top guide bar. This extension has ample bearing in its support, being set with the flat faces at an angle of 45 degs. It connects at the rear to the combination lever, the details of which are shown in the illustration, through a specially designed pin, also illustrated. This pin is arranged with a central passage and outlets in the center of the bearing, through which the lubricant can reach the bearing surfaces.

The eccentric crank is of cast steel in one piece, being fitted over a 5 in. diameter extension on the end of the crank pin and secured in place by a bolt passing through it and the main pin. The construction and arrangements of the other parts of the gear are clearly shown in the detailed illustrations.

The general dimensions, weights, and ratios of both types of locomotives are given in the following table:

GENERAL DATA.		
Type	Pacific	Consolidation
Gauge	4 ft. 8½ ins.	4 ft. 8½ in.
Service	Passenger	Freight
Fuel	Oil	Oil
Tractive effort	32,600 lbs.	43,970 lbs.
Weight in working order	232,750 lbs.	212,400 lbs.
Weight on drivers	140,400 lbs.	183,200 lbs.
Weight on leading truck	54,950 lbs.	29,200 lbs.
Weight on trailing truck	37,400 lbs.	....
Wt. of engine and ten. in work. order	395,000 lbs.	375,000 lbs.
Wheel base, driving	12 ft. 8 in.	15 ft. 6 in.
Wheel base, total	34 ft. 5 in.	24 ft. 6 in.
Wheel base, engine and tender	65 ft.	58 ft. 3 in.
RATIOS.		
Weight on drivers ÷ tractive effort	4.33	4.17
Total weight ÷ tractive effort	7.12	4.75
Trac. ef. × diam. driv. ÷ heat. surf.	700.00	855.00
Total heating surface ÷ grate area	68.50	62.00
Fireb'x heat. surf. ÷ t'l heat. surf., %	5.60	5.35
Weight on drivers ÷ total heat. surf.	41.50	62.50
Total weight ÷ total heating surf.	68.50	72.50
Volume both cylinders, cu. ft.	16.00	16.80
Total heating surf. ÷ vol. cylinders	212.00	174.50
Grate area ÷ vol. cylinders	3.10	2.82
CYLINDERS.		
Kind	Simple	Simple
Diameter and stroke	25 × 28 in.	24 × 32 in.
VALVES.		
Kind	Piston	Piston
Diameter	13 in.	13 in.
Greatest travel	6¼ in.	....

Outside lap	$1\frac{1}{8}$ in.	....
Inside clearance	$\frac{1}{8}$ in.	....
Lead. constant	$\frac{1}{4}$ in.	....
Valve gear	Walsch.	Walsch.
WHEELS.		
Driving, diameter over tires	73 in.	57 in.
Driving, thickness of tires	$3\frac{1}{2}$ in.	$3\frac{1}{2}$ in.
Driv. jour., main diam. and length	10 × 12 in.	10 × 12 in.
Driv. jour., others, diam. and length	9 × 12 in.	9 × 12 in.
Engine truck wheels, diameter	$34\frac{1}{4}$ in.	$29\frac{1}{4}$ in.
Engine truck, journals	6 × 10 in.	$6\frac{1}{2}$ × $10\frac{1}{2}$ in.
Trailing truck wheels diameter	50 in.	....
Trailing truck, journals	8 × 14 in.	....
BOILER.		
Style	Straight	Straight
Working pressure	160 lbs.	160 lbs.
Outside diameter of first ring	72 in.	$78\frac{3}{4}$ in.
Firebox, length and width	108 × 66 in.	$95\frac{1}{2}$ × $71\frac{1}{4}$ in.
Firebox, plates, thickness	$\frac{3}{8}$ & $\frac{9}{16}$ in.	$\frac{3}{8}$ & $\frac{1}{2}$ in.
Firebox, water space	F-$4\frac{1}{2}$, S-5, B-4 in.	F-$4\frac{1}{2}$, S & B-4 in.
Tubes, number and outside diam	273–$2\frac{1}{4}$ in.	355–2 in.
Tubes, length	20 ft.	15 ft.
Heating surface, tubes	3,202 sq. ft.	2,773 sq. ft.
Heating surface, firebox	190 sq. ft.	157 sq. ft.
Heating surface, total	3,392 sq. ft.	2,930 sq. ft.
Superheater heating surface	759 sq. ft.	600 sq. ft.
Grate area	49.5 sq. ft.	47.4 sq. ft.
Smokestack, height above rail	$184\frac{1}{4}$ in.	$185\frac{7}{8}$ in.
Centre of boiler above rail	$114\frac{1}{4}$ in.	114 in.

TENDER (BOTH TYPES)

Tank	Waterbottom
Frame	12 in. channels
Wheels, diameter	$34\frac{1}{4}$ in.
Journals, diameter and length	$5\frac{1}{2}$ × 10 in.
Water capacity	8,500 gals.
Oil capacity	3,300 gals.

VANADIUM IN CAST IRON.*

For a number of years admirable reports on alloys research have come from Europe, and among them one would occasionally see mention of vanadium and its remarkable effect on steel. The practical steel-maker, however, knowing the high price of this rare metal could only regret that vanadium had no commercial application.

Since the discovery recently of enormous deposits of vanadium, more particularly those in Colorado, matters have assumed a different shape. Prof. Hildebrand, of the U. S. Geological Survey, first located a deposit of vanadi-ferous sandstone in that state, and this is now being worked extensively, and the ferro-alloy made right in this country. The supply of vanadium is practically unlimited.

The properties of vanadium steel are as follows: The elastic limit is increased without an impairment of the ductility of the steel—that is, an exceedingly strong steel is obtained, with its softness still remaining. Coupled with these most valuable properties is another, and that is the extreme resistance to deterioration when the metal is subjected to severe and continued strains in service. Vanadium steel is nonfatiguing, and, therefore, an ideal railroad and rolling mill metal. It is but natural that attention should be drawn to the use of vanadium in the foundry. The very first casting which might be benefited is the car wheel. Next would come the various kinds of rolls, then alkali pots, pump parts, etc.—wherever strains are heavy and oft repeated, either direct tension and compression alternately and in cases where castings are subjected to shock or great variations in temperature.

In order to learn something of the effects of vanadium on cast iron a series of tests was conducted, using melted scrapped car wheels for white iron and a good machinery pig iron for a variety of gray iron. A ferrovanadium carrying high carbon was selected because it melted at a lower temperature and would also be cheaper for the foundryman. Varying proportions were added to the ladle full of molten metal, first in lump form, and, as this did not give satisfaction with the small quantities of iron used at a time, the alloy was powdered before using.

Inasmuch as vanadium, besides being a great strengthener, is also a powerful deoxidizing agent, and the increase in strength obtained by its use might be attributed to the purification of the iron only, a further series of tests was included in which the ladle was first treated with 80 per cent. ferromanganese in sufficient quantity to add 0.5 per cent. of manganese, and then the ferrovanadium. In order to obtain some light on the deoxidizing power of vanadium a set of tests was also made with burnt metal, the results of which are given in the tables below.

* From a paper delivered before the American Foundrymen's Association by Dr. Richard Moldenke, Secretary of the Association.

The test bars were of the regulation kind, as prescribed by the American Society for Testing Materials—namely $1\frac{1}{4}$ in. round, cast on end, and in dried molds. The test bars, dumped when cold, were only brushed and then broken transversely on a 5000-lb. Riehle testing machine. As there were quite a lot of tests, and many of the bars varied slightly in diameter from the standard, the breaking weights were all recalculated from the modulus of rupture back to the standard $1\frac{1}{4}$-in. test bar. This, while not correct in its strictest sense, for cast iron is not homogeneous and does not follow the rules applicable to steel, nevertheless gives a fair comparison of the general effects of the alloy addition.

TABLE I.

Burnt Iron, Gray (Burnt grate bars, stove iron, etc.)

Average of 5 bars—no vanadium added:	
Broke at	1,310 lbs.
Deflection	.09 in.
Modulus of rupture	25,500 lbs.
Average of 3 bars—.05 per cent. vanadium added:	
Broke at	2,220 lbs.
Deflection	.1 in.
Modulus of rupture	43,380 lbs.

TABLE II.

Burnt Iron. White.

Average of 3 bars—no vanadium added:	
Broke at	1,440 lbs.
Deflection	.05 in.
Modulus of rupture	28,170 lbs.
Average of 12 bars—.50 manganese and .05 vanadium added:	
Broke at	1,910 lbs.
Deflection	.055 in.
Modulus of rupture	37,400 lbs.

TABLE III.

Machinery Iron. Gray (melted pig—no scrap).

Average of 5 bars—no vanadium added:	
Broke at	1,980 lbs.
Deflection	.105 in.
Modulus of rupture	38,680 lbs.
Average of 5 bars—.05 vanadium added:	
Broke at	2,070 lbs.
Deflection	.105 in.
Modulus of rupture	40,410 lbs.
Average of 19 bars—.10 vanadium added:	
Broke at	2,200 lbs.
Deflection	.115 in.
Modulus of rupture	42,600 lbs.
Average of 4 bars—.15 vanadium added:	
Broke at	2,740 lbs.
Deflection	.13 in.
Modulus of rupture	53,750 lbs.
Average of 3 bars—.5 manganese added, no vanadium:	
Broke at	1,970 lbs.
Deflection	.1 in.
Modulus of rupture	38,410 lbs.
Average of 5 bars—.05 ground vanadium added:	
Broke at	1,980 lbs.
Deflection	.1 in.
Modulus of rupture	38,700 lbs.
Average of 4 bars—.5 Mn. and .05 ground vanadium added:	
Broke at	2,130 lbs.
Deflection	.1 in.
Modulus of rupture	41,780 lbs.
Average of 5 bars—.10 ground vanadium added:	
Broke at	2,372 lbs.
Deflection	.09 in.
Modulus of rupture	46,320 lbs.
Average of 3 bars—.5 Mn. and .10 ground vanadium added:	
Broke at	2,530 lbs.
Deflection	.12 in.
Modulus of rupture	49,590 lbs.
Average of 5 bars—.15 ground vanadium added:	
Broke at	2,360 lbs.
Deflection	.1 in.
Modulus of rupture	46,070 lbs.

TABLE IV.

Remelted Car Wheels. White—no pig iron.

Average of 5 bars—no vanadium:	
Broke at	1,470 lbs.
Deflection	.05 in.
Modulus of rupture	28,100 lbs.
Average of 5 bars—.05 lump vanadium added:	
Broke at	2,190 lbs.
Deflection	.05 in.
Modulus of rupture	41,570 lbs.
Average of 7 bars—.10 lump vanadium added:	
Broke at	2,050 lbs.
Deflection	.05 in.
Modulus of rupture	39,750 lbs.
Average of 8 bars—.15 lump vanadium added:	
Broke at	2,264 lbs.
Deflection	.06 in.
Modulus of rupture	44,480 lbs.
Average of 4 bars—.50 Mn. and no vanadium:	
Broke at	2,790 lbs.
Deflection	.07 in.
Modulus of rupture	54,570 lbs.
Average of 6 bars—.05 ground vanadium:	
Broke at	3,020 lbs.
Deflection	.06 in.
Modulus of rupture	59,030 lbs.
Average of 6 bars—.50 Mn. and .05 ground vanadium added:	
Broke at	2,970 lbs.
Deflection	.09 in.
Modulus of rupture	58,040 lbs.
Average of 3 bars—.10 ground vanadium:	
Broke at	2,800 lbs.
Deflection	.055 in.
Modulus of rupture	54,890 lbs.

Average of 4 bars—.50 Mn. and .10 ground vanadium added:
Broke at ....3,030 lbs.
Deflection .... .09 in.
Modulus of rupture ....59,220 lbs.
Average of 6 bars—.15 ground vanadium:
Broke at ....2,950 lbs.
Deflection .... .07 in.
Modulus of rupture ....59,230 lbs.
Average of 6 bars—.50 Mn. and .15 ground vanadium added:
Broke at ....3,920 lbs.
Deflection .... .095 in.
Modulus of rupture ....76,650 lbs.

The analyses were for the most part made on bars in which the powdered alloy was used, as these tests were most satisfactory. All tests, however, are given as they seem to confirm the belief that the addition to the strength of the metal is a well-founded one. The vanadium alloy used contained

Vanadium	14.67
Carbon	6.36
Silicon	0.18

While the vanadium content is comparatively low, this is a very good alloy for foundry purposes, as cast iron is already high in carbon, and the silicon is too small to cut an appreciable figure in the results. While the attempt was made to get as nearly 0.5, 0.10 and 0.15 vanadium into the ladles of metal as possible, the analyses show that for the bars selected (as nearly the average for strength as possible) as much as two or three times actually remained after casting. This is due first to the impossibility of accurately weighing out in the small space of time available to prevent undue cooling of the metal, most of the time dealing with less metal in the ladle than expected or arranged for. Then, with the small quantities tried, the chances for irregular distribution were very great. A foundry with 5 or 10 ton ladles would give a better opportunity. Finally there is the uncertainty of how much or little vanadium is oxidized. The very best results with both manganese and vanadium show very little of the latter remaining.

The results, however, are sufficient to strongly recommend the new alloy to the consideration of foundrymen. If but a part of the resistance of deterioration found by adding vanadium to steel should be proven by service trials to exist in cast iron, then on the score of safety to human life alone, the metal belongs in every car wheel. A still better method would be to use a more powerful deoxidizer than manganese and add the vanadium on top of it.

The results shown in the tables speak for themselves, and the averages tallied off for each table show a remarkable progression of values. To increase the breaking strength of a test bar from 2000 up to 2500 for gray iron, and 1500 up to 3900 for white iron is sufficient to warrant further investigation on the part of every foundryman who has special problems in strength to master, and this part of the investigations is therefore given to the foundry public at this time, rather than to wait for the further tests still on the programme. It is expected to continue the investigations on vanadium in cast iron further, making provision to keep the ladle with melted iron heated up for a fairly long period, so that better mixing of the alloy may result, and hence more accurate results can be obtained.

Elkhart Roundhouse Burns.—A large section of both roundhouses, together with the accompanying repair shop and storeroom of the Lake Shore & Michigan Southern Railway, at Elkhart, Ind., were destroyed by fire on the morning of January 9. The fire started by the ignition and explosion of a barrel of front end paint located in the store-room, and spread with such incredible rapidity that in spite of the splendid work of the shop and city fire departments, it destroyed all of the shop building, with the exception of the oil house, as well as eight stalls in each of the roundhouses, before being brought under control. On practically all of these stalls were locomotives, and since one of the first effects of the fire was to destroy the electrical connection to the turn-tables, it was impossible to remove even such of these locomotives as had steam pressure, and they were all badly burned and will require a complete overhauling. Work of rebuilding the structures was started as soon as the ruins had cooled.

HOLLOW STAYBOLTS.

By John Hickey.*

Having been troubled with broken staybolts on several mountain engines, due to variation of pressure followed by extremes of temperature several times a day, the writer had some hollow staybolts placed on surfaces giving the most trouble from broken bolts. As the solid staybolts and those having drilled telltales were removed, they were replaced by hollow ones. After about a year of this practice it was noticed that the staybolt work at the short run terminals was very materially reduced. Prior to this the life of the solid staybolt with telltale drilling was between five and nine months, depending on location in staying, while after this time, a little over a year, there was no record of a single hollow bolt being broken, although located mostly in what was considered the breaking zone. Longer periods of experience with the hollow bolt developed equally good results, its endurance being remarkable under the severe conditions existing.

The self-warning principle of the hollow staybolt is highly appreciated by those directly in touch with the power generator. Eliminating the hammer tests, together with the feeling that no dangerous number can be broken without compelling attention, is regarded as a very satisfactory condition. It is well known that the strength of wrought iron decreases after reaching 350 degrees F. Moderately high firebox temperature causes a solid staybolt to reach the depreciative heat, this being one of the causes which shortens its life. With the hollow staybolts in service a streamlet of cool air passes through each bolt to the furnace, thus holding the metal at a lower temperature, furnishing both strength and endurance that cannot be obtained with the use of the highest possible grade of iron in the solid staybolt. The greater endurance of the inner ends of the hollow bolts, as compared with solid ones, is very noticeable. This is due to the in-rushing air through the hollow bolts cooling the ends of the bolts and reducing the waste of the iron due to the high heat of the fire.

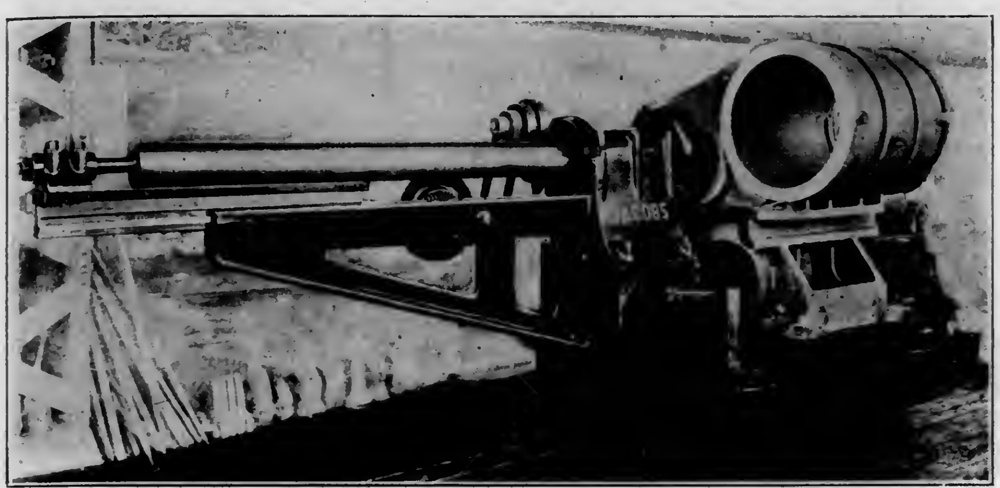
It is said that a few have closed the center holes at the inner ends of the hollow staybolts with a couple of blows of the hammer, claiming the entrance of too much cold air. This practice, the writer is certain, should be discouraged. In order to obtain full benefits from the hollow bolts, the air should be permitted to pass through the ⅛-in. hole to the fire. This will hold the staybolt to lower temperature, add to its strength and flexibility, cause greater endurance to the inner ends, and while aiding combustion will add noticeably to the efficiency of the furnace. It will further afford a double advantage for the detection of breakages should any occur, as the annular hole passes entirely through the bolt and failure at any point will immediately make itself known.

Hollow staybolts with both ends open will never stop up, as the current of air passing through them always keeps the holes free from sediment. Furthermore, the hollow bolt saves material and time in application and renewals, and also prevents injury to sheets in making renewals, as the operator has a central hole for his drill to follow.

* Salt Lake City.

The Next World's Fair.—Work on the grounds and buildings of the Alaska-Yukon-Pacific Exposition, which will be held at Seattle, Washington, June 1 to October 15, 1909, is well under way and the management has announced that beyond doubt the work of building, grading, etc., will be completed on the opening day. This fair differs from previous fairs in many ways, the first of which is that the National Government has not been asked for any money to carry on the work.

Issue of Patent Four Weeks from Allowance.—As most inventors know, it has hitherto been the practice of the United States Patent Office to issue patents on inventions three weeks after the date of allowance on payment of the final government fee. The Commissioner of Patents has given instructions that hereafter the period between the date of allowance and the issue of the patent shall be four weeks.—*Scientific American.*



SINGLE BAR BORING MACHINE, A. T. & S. F. RY.

SINGLE BAR BORING MACHINE FOR MULTIPLE CYLINDERS.

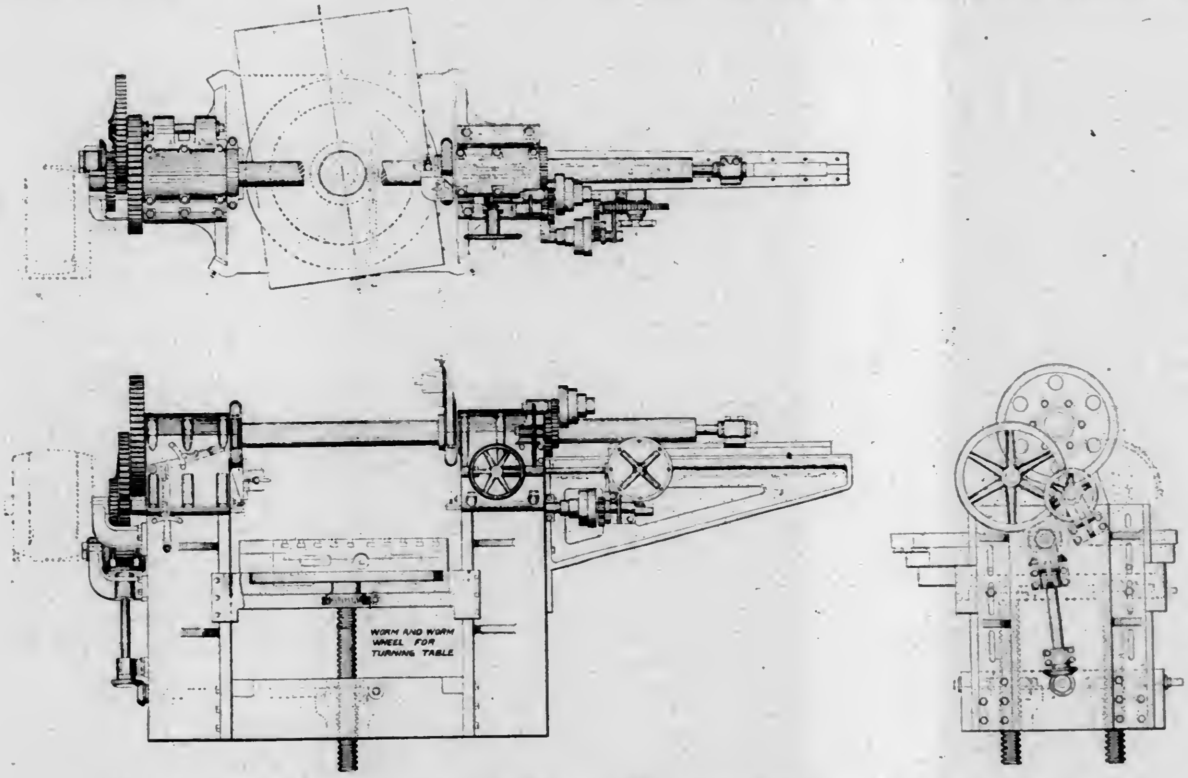
By E. J. McKernan.*

The usual locomotive cylinder boring machine consists of a horizontal spindle and table permitting of either no adjustment at all or only lateral adjustment. With these machines of the old design much time is consumed in properly setting the cylinder so that the boring bar will strike the true center, and furthermore, high speeds and rapid cutting cannot be obtained. These disadvantages are, of course, magnified when cylinder castings having two or more cylindrical chambers are to be bored and faced, because the work has to be set twice, and the cylinders and valve chambers (where piston valves are used) must be truly parallel with each other. These machines, designed when simple slide valve cylinders of not more than 18 in. or 20 in. in diameter were the prevailing type on locomotives, were adapted for use with the slow speed carbon steel which was the most efficient material for making cutting tools at that time. The mechanism was simple, but the driving and feed gears were weak cast iron affairs which drove the tool along at an unprofitably slow speed. Later, as the art of cutting materials was on a more scientific basis, and tool steels of greater cutting capacity and speed were introduced in shop practice, attempts to work these new cutting tools to their proper limits in boring machines of this class, would result in stripping the gears, or other injury to the machine.

* Tool Expert, A. T. & S. F. R'y System.

With the later developments in high speed cutting tools of great capacity, and in locomotive construction, with engines having piston valves and often compound cylinders on the Vauclain principle or on the four cylinder balanced compound principle, a machine capable of the most effective service under the latter conditions becomes a shop necessity. In order to meet this demand, one manufacturer produced a three-spindle machine which would require but one setting of the work and which would insure the parallel boring of all cylinders and chambers. While this type of machine possesses many advantages for certain classes of work, still the single bar machine has been found superior for general railroad practice. A comparison of the two types shows that the single bar has less gearing and is the simpler machine, and is consequently much easier maintained. On account of the smaller number of parts, the single bar machine is the most economical to drive, and the power required can be obtained from a small motor. Where there are some advantages in boring three chambers at once it has been found in practice that the chatter in one tool is transmitted to the other tools causing a rough finish in all bores. This, of course, is entirely obviated in the single bar machine. From experience in the ordinary railroad shop it has been found that the single bar machine is best suited to all-around locomotive work. It is economical in operation, in power consumed and in adjustments, and, owing to the less machinery involved, it is the most economical to buy.

Recently there have been built several heavy and solid single bar boring machines with the boring bars capable of the heaviest



PLAN AND ELEVATIONS OF SINGLE BAR BORING MACHINE AT THE TOPEKA SHOPS OF THE SANTA FE.

Average of 6 bars .50 Mn. and .10 ground vanadium added:
Broke at ....3,030 lbs.
Deflection .... .09 in.
Modulus of rupture ....59,220 lbs.
Average of 6 bars .15 ground vanadium:
Broke at ....2,950 lbs.
Deflection .... .07 in.
Modulus of rupture ....59,230 lbs.
Average of 6 bars .50 Mn. and .15 ground vanadium added:
Broke at ....3,920 lbs.
Deflection .... .095 in.
Modulus of rupture ....76,650 lbs.

The analyses were for the most part made on bars in which the powdered alloy was used, as these tests were most satisfactory. All tests, however, are given as they seem to confirm the belief that the addition to the strength of the metal is a well founded one. The vanadium alloy used contained:

Vanadium	14.67
Carbon	0.36
Silicon	0.18

While the vanadium content is comparatively low, this is a very good alloy for foundry purposes, as cast iron is already high in carbon, and the silicon is too small to cut an appreciable figure in the results. While the attempt was made to get as nearly 0.5, 0.10 and 0.15 vanadium into the ladles of metal as possible, the analyses show that for the bars selected (as nearly the average for strength as possible) as much as two or three times actually remained after casting. This is due first to the impossibility of accurately weighing out in the small space of time available to prevent undue cooling of the metal, most of the time dealing with less metal in the ladle than expected or arranged for. Then with the small quantities tried, the chances for irregular distribution were very great. A foundry with 5 or 10 ton ladles would give a better opportunity. Finally there is the uncertainty of how much or little vanadium is oxidized. The very best results with both manganese and vanadium show very little of the latter remaining.

The results, however, are sufficient to strongly recommend the new alloy to the consideration of foundrymen. If but a part of the resistance of deterioration found by adding vanadium to steel should be proven by service trials to exist in cast iron, then on the score of safety to human life alone, the metal belongs in every car wheel. A still better method would be to use a more powerful deoxidizer than manganese and add the vanadium on top of it.

The results shown in the tables speak for themselves, and the averages [illegible] for each table show a remarkable progression of values. To increase the breaking strength of a test bar from 2000 up to 2500 for gray iron, and 1500 up to 3000 for white iron is sufficient to warrant further investigation on the part of every foundryman who has special problems in strength to master, and this part of the investigation is therefore given to the foundry public at this time, rather than to wait for the further tests still on the programme. It is expected to continue the investigations on [illegible] further, making provision to keep the ladle with melted iron heated up for a fairly long period, so that better mixing of the alloy may result, and hence more accurate results can be obtained.

Elkhart Roundhouse Burns.—A large section of both roundhouses, together with the accompanying repair shop and store room of the Lake Shore & Michigan Southern Railway, at Elkhart, Ind., were destroyed by fire on the morning of January 6. The fire started by the ignition and explosion of a barrel of front end paint located in the store room, and spread with such incredible rapidity that in spite of the splendid work of the shop and city fire departments, it destroyed all of the shop building, with the exception of the oil house, as well as eight stalls in each of the roundhouses, before being brought under control. On practically all of these stalls were locomotives, and since one of the first effects of the fire was to destroy the electrical connection to the turntables, it was impossible to remove even such of these locomotives as had steam pressure, and they were all badly burned and will require a complete overhauling. Work of rebuilding the structures was started as soon as the ruins had cooled.

HOLLOW STAYBOLTS.

By John Hickey.*

Having been troubled with broken staybolts on several mountain engines, due to variation of pressure followed by extremes of temperature several times a day, the writer had some hollow staybolts placed on surfaces giving the most trouble from broken bolts. As the solid staybolts and those having drilled telltales were removed, they were replaced by hollow ones. After about a year of this practice it was noticed that the staybolt work at the short run terminals was very materially reduced. Prior to this the life of the solid staybolt with telltale drilling was between five and nine months, depending on location in staying, while after this time, a little over a year, there was no record of a single hollow bolt being broken, although located mostly in what was considered the breaking zone. Longer periods of experience with the hollow bolt developed equally good results, its endurance being remarkable under the severe conditions existing.

The self-warning principle of the hollow staybolt is highly appreciated by those directly in touch with the power generator. Eliminating the hammer tests, together with the feeling that no dangerous number can be broken without compelling attention, is regarded as a very satisfactory condition. It is well known that the strength of wrought iron decreases after reaching 350 degrees F. Moderately high firebox temperature causes a solid staybolt to reach the depreciative heat, this being one of the causes which shortens its life. With the hollow staybolts in service a streamlet of cool air passes through each bolt to the furnace, thus holding the metal at a lower temperature, furnishing both strength and endurance that cannot be obtained with the use of the highest possible grade of iron in the solid staybolt. The greater endurance of the inner ends of the hollow bolts, as compared with solid ones, is very noticeable. This is due to the in-rushing air through the hollow bolts cooling the ends of the bolts and reducing the waste of the iron due to the high heat of the fire.

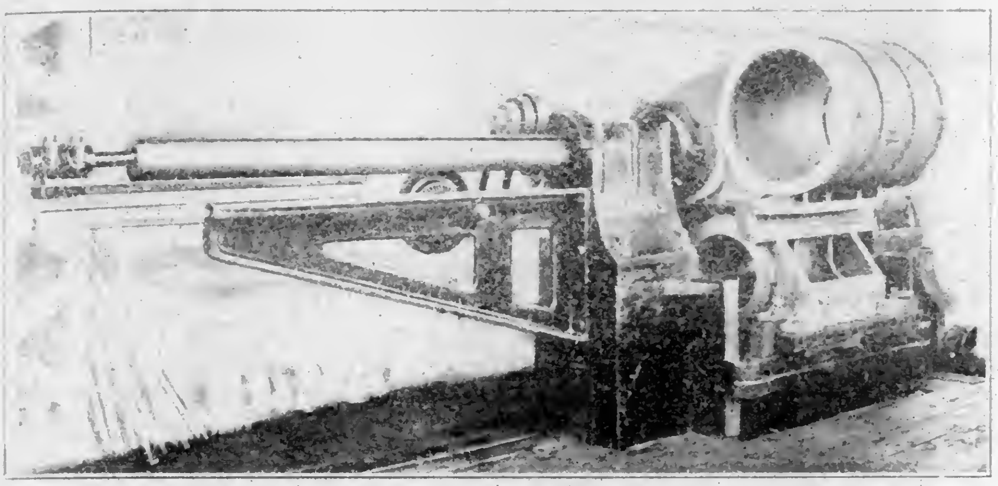
It is said that a few have closed the center holes at the inner ends of the hollow staybolts with a couple of blows of the hammer, claiming the entrance of too much cold air. This practice, the writer is certain, should be discouraged. In order to obtain full benefits from the hollow bolts, the air should be permitted to pass through the $\frac{3}{16}$ in. hole to the fire. This will hold the staybolt to lower temperature, add to its strength and flexibility, cause greater endurance to the inner ends, and while aiding combustion will add noticeably to the efficiency of the furnace. It will further afford a double advantage for the detection of breakages should any occur, as the annular hole passes entirely through the bolt and failure at any point will immediately make itself known.

Hollow staybolts with both ends open will never stop up, as the current of air passing through them always keeps the holes free from sediment. Furthermore, the hollow bolt saves material and time in application and renewals, and also prevents injury to sheets in making renewals, as the operator has a central hole for his drill to follow.

* [illegible]

The Next World's Fair.—Work on the grounds and buildings of the Alaska-Yukon Pacific Exposition, which will be held at Seattle, Washington, June 1 to October 15, 1909, is well under way and the management has announced that beyond doubt the work of building, grading, etc., will be completed on the opening day. This fair differs from previous fairs in many ways, the first of which is that the National Government has not been asked for any money to carry on the work.

Issue of Patent Four Weeks from Allowance.—As most inventors know, it has hitherto been the practice of the United States Patent Office to issue patents on inventions three weeks after the date of allowance on payment of the final government fee. The Commissioner of Patents has given instructions that hereafter the period between the date of allowance and the issue of the patent shall be four weeks.—*Scientific American.*



SINGLE BAR BORING MACHINE, A. T. & S. F. RY.

SINGLE BAR BORING MACHINE FOR MULTIPLE CYLINDERS.

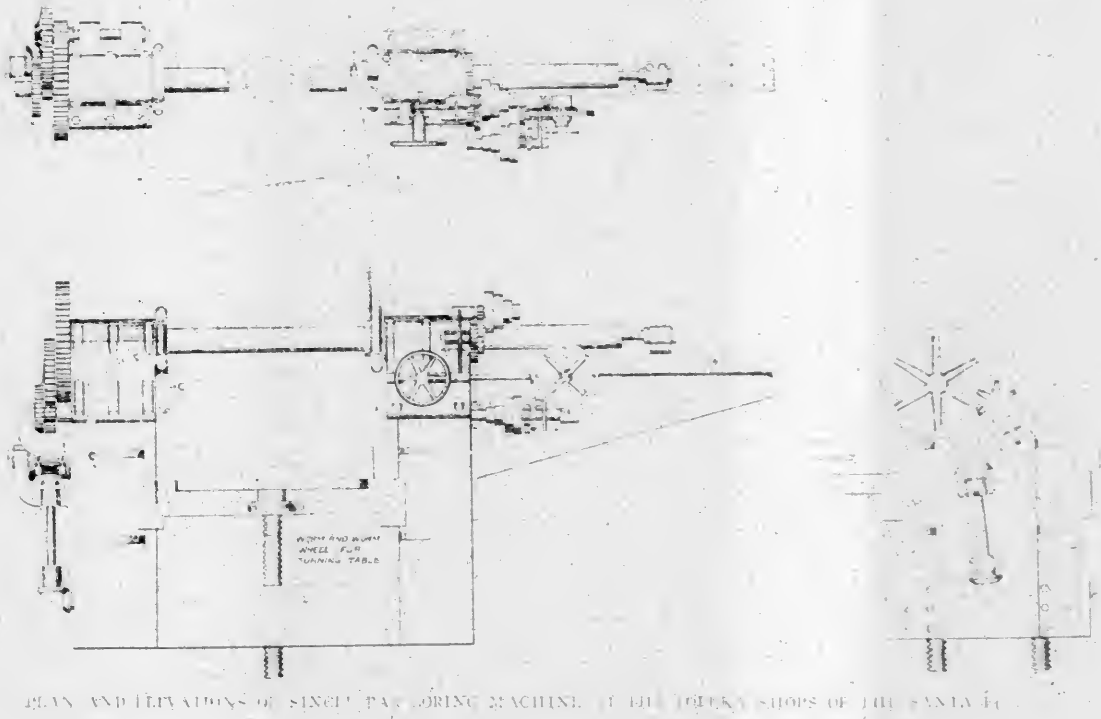
By E. J. McKernan.*

The usual locomotive cylinder boring machine consists of a horizontal spindle and table permitting of either no adjustment at all or only lateral adjustment. With these machines of the old design much time is consumed in properly setting the cylinder so that the boring bar will strike the true center, and furthermore, high speeds and rapid cutting cannot be obtained. These disadvantages are, of course, magnified when cylinder castings having two or more cylindrical chambers are to be bored and faced, because the work has to be set twice, and the cylinders and valve chambers (where piston valves are used) must be truly parallel with each other. These machines, designed when simple slide valve cylinders of not more than 18 in. or 20 in. in diameter were the prevailing type on locomotives, were adapted for use with the slow speed carbon steel which was the most efficient material for making cutting tools at that time. The mechanism was simple, but the driving and feed gears were weak cast iron affairs which drove the tool along at an unprofitably [illegible] speeds. Later, as the art of cutting [illegible] [illegible] greater [illegible] capacity and [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] machine.

With the later development of high speed cutting tools of great capacity, and [illegible] locomotive construction with [illegible] piston valves and other compound cylinders on the Vauclain principle or on the four cylinder balanced compound principle, a machine capable of the most effective service under the latter conditions becomes a shop necessity. In order to meet this demand, one manufacturer produced a three-spindle machine which would require but one setting of the work and which would insure the parallel boring of all cylinders and chambers. While this type of machine possesses many advantages for certain classes of work, still the single bar machine has been found superior for general railroad practice. A comparison of the two types shows that the single bar has less gearing and is the simpler machine, and is consequently much easier maintained. On account of the smaller number of parts, the single bar machine is the most economical to drive, and the power required can be obtained from a small motor. Where there are some advantages in boring three chambers at once it has been found in practice that the chatter in one tool is transmitted to the other tools causing a rough finish in all bores. This, of course, is entirely obviated in the single bar machine. From experience in the ordinary railroad shop it has been found that the single bar machine is best suited to all-around locomotive work. It is economical in operation, in power consumed and in adjustments, and, owing to the less machinery involved, it is the most economical to buy.

Recently there have been built several heavy and solid single bar boring machines with the boring bars capable of the heaviest

* [illegible], A. T. & S. F. Ry. System.



PLAN AND ELEVATIONS OF SINGLE BAR BORING MACHINE AT THE TOPEKA SHOPS OF THE SANTA FE.

strains, and of such a design as to insure working the cutting tools to the very highest capacity. The accurate setting of the work, especially in connection with the multiple cylinders, is brought about by the application of a table having both lateral and vertical adjustment, and these machines produce very excellent work. But the examples of them thus far constructed are heavy ponderous affairs, costing a great deal for the weight of metal in them alone, and they do not have the universally wide range for accommodating all classes of locomotive cylinder boring that should be a requisite in modern machines for this purpose. Their first cost is high, and the best results are not always obtained from them, not to speak of the relative large amount of shop room required.

At the Topeka shops of the Santa Fé Railway there has been built a cylinder boring mill which answers all the requirements in regard to the boring of cylinders for all classes of compound engines. This machine is also adapted to bore cylinders on engines which have one cylinder or chamber at an angle to the others. All cylinders or chambers may be bored at one clamping of the cylinder, by the mere raising or lowering of the table. This table has an elevating movement of 37 in.; also has a cross travel of 35 in. The table which has the cross travel movement has also a swiveling motion, by which a range of 15 degrees incline may be had.

This new boring mill, as can be seen in the illustration, is direct motor driven. The table is raised or lowered by power connection with the main motor through beveled gears and clutches, handled from the operator's side of the machine. All the mechanism is of the latest design and is strong and durable, all gears being made from good gray iron and all bushings of phosphor bronze. The boring bar is 7 in. in diameter and is made from open hearth steel. It is fed through the cylinder by means of a spur gear and rack which makes it very rigid in operation and gives a very smooth bore.

One of the facing heads on the machine is made so that it will move along on the bar and is driven by means of a 1-in. key and set screw, and will pull any kind of a cut that is put on the machine. The facing heads are fed by means of a star feed attachment. The screws that elevate the table are made from soft steel and are 5½ in. in diameter and are ¾ pitch, the screws set at right angles to the boring bar, making everything rigid. The total weight is about 15 tons, and the machine takes up floor space of 223 sq. ft., having an extreme length of 21 ft. and an overall range in width of 14 ft.

This machine is capable of boring a three-chamber compound cylinder in 15 hours or in a year of 3,000 working hours you can bore 200 three-chamber compound cylinders. You can also bore a simple cylinder in three hours or 1,000 in a year of 3,000 working hours.

On the old style boring mill it has taken from 26 to 28 hours to bore a three-chamber compound cylinder. Thus, by the use of this modern boring mill, 11 hours can be saved on each three-chamber compound cylinder, where it used to take from 8 to 10 hours to bore a simple cylinder. One of these cylinders can now be bored in three hours on this machine; thus making a saving of 5 hours on each simple cylinder bored, or over $1,500 a year in operator's wages alone, in addition to increasing the machine capacity from only 375 cylinders per year, to 1,000 simple cylinders, giving an output of 625 more cylinders per year. Where only 115 three-chamber compound cylinders could be handled with the old style boring mill, the new machine will bore 200 cylinders, thus increasing the output of compound cylinders about 77 per cent.

If a machine which bores only one chamber of a locomotive cylinder casting at one time is to compete successfully with one which can bore three chambers simultaneously, it must not only bore rapidly, but it must be so constructed so that only one setting will be required to bring the chambers into position to bore. This arrangement has been attained in this new machine, insuring that after a cylinder has been lined up and clamped on the table any of the chambers may be brought exactly into position for boring and making it impossible to bore two chambers out of parallel unless desired.

The machine of this design which has been in operation for some time at the Topeka shops is giving first-class satisfaction, both in its convenience in handling, and in the lower production cost. It is understood that arrangements have been made for the Tool and Railway Specialty Manufacturing Company of Atchison, Kansas, to handle machines of this type on the market.

CAST STEEL TRUCK BOLSTER.

A satisfactory truck bolster requires great strength in the horizontal, as well as in the vertical, plane, combined with a certain amount of elasticity, and should also be as light in weight as possible. The accompanying illustration shows a bolster which has been designed with all of these conditions, together with a number of minor requirements, kept clearly in view. It is made of cast steel in one piece, in the form of a truss, the tension member being a solid thin plate of cast steel, the compression member being considerably wider, and of greater section at the edges, is cut out on either side of the center plate to secure light-

ness. The sides forming the vertical and diagonal members are inclined and provide simply sufficient metal to properly take care of the stresses, the useless material being cut out, as is shown in the illustration. The inclination of the sides permits them to assist somewhat in carrying the horizontal as well as the vertical stresses, and also allows the use of a deeper truss by giving a tension member of a width which will give a clearance between the flanges of the commonly inverted channel iron or angles forming the truck cross tie. At the same time a compression member of even greater width and strength than usual is obtained. The side bearings, center plate and dead lever fulcrum are cast integral with the bolster, doing away with all riveting.

These bolsters are made to suit any dimensions or to carry any desired weight. Trials on a testing machine have shown that the bolster for a 60,000-lb load will show no permanent set at 100,000 lbs., and has an ultimate breaking load of 200,000 lbs. The 100,000-lb. bolster shows no set at 150,000, and breaks between 325,000 and 400,000 lbs.

This bolster is designed and is being manufactured and sold by the Gould Coupler Company, 341 Fifth avenue, New York.

PERSONALS.

J. F. Marshall has been appointed general store keeper of the Wabash Railroad at Canton, Ohio.

H. Sayles, one of the pioneer railroad men of Buffalo, N. Y., died recently at his home in that city.

The office of general master mechanic of the International & Great Northern R. R. has been abolished.

James McDonough has been appointed general foreman of the Trinity & Brazos Valley Ry. at Galveston, Texas.

J. T. Lendrum has been appointed master mechanic of the Oklahoma division of the Santa Fe, with office at Arkansas City, Kan.

C. H. Kessler has been appointed mechanical engineer of the El Paso & Southwestern R. R., with headquarters at El Paso, Texas.

G. W. Taylor, master mechanic of the Oklahoma division of the Santa Fe, has been transferred to the Middle division at Newton, Kan.

E. F. Fay, master mechanic of the Union Pacific R. R. at Denver, Colo., has been transferred to Cheyenne, Wyo., as superintendent of shops.

J. A. Doarnberger has been appointed master boiler maker of the Norfolk & Western Ry., with jurisdiction of the boiler work of the whole system.

J. G. McLaren has been appointed master mechanic of the Chicago, Rock Island & El Paso Ry., with office at Dalhart, Tex., in place of J. McDonough.

J. L. Sydnor, formerly bonus supervisor of the Coast Lines of the Santa Fe, has been transferred to Topeka as bonus supervisor of the Eastern Grand Division.

J. A. Turtle, assistant superintendent of motive power of the Union Pacific R. R., has been transferred to Denver, Colo., succeeding E. F. Fay as master mechanic.

J. F. Whiteford, general roundhouse inspector of the Santa Fe, has been appointed bonus supervisor of the Coast Lines, with headquarters at San Bernardino, Cal.

Michael Flanagan has been appointed master mechanic of the Montana division of the Great Northern Ry. at Havre, Mont., in place of K. Froburg, transferred.

G. J. DeVilbiss, superintendent of motive power of the Toledo & Ohio Central Ry., has had his jurisdiction extended to include the Marietta, Columbus & Cleveland R. R.

The office of J. S. Chambers, superintendent of motive power of the Atlantic Coast Line, has been changed from Wilmington, N. C., to South Rocky Mount, N. C.

A. Dinan, master mechanic of the Middle division of the Santa Fe, has been transferred to the Missouri division, with office at Fort Madison, Ia., in place of J. H. McGoff, promoted.

T. S. Reilly, associate editor of the *Railway and Engineering Review*, at Chicago, has resigned, to become superintendent of the mechanical department of the Canton & Hankow Railway at Canton, China.

C. F. Harding has been appointed professor of the school of electrical engineering at Purdue University. Prof. Harding comes from Cornell, where he has held the position of associate professor of electrical engineering.

Charles E. Fuller, until recently superintendent of motive power of the Chicago & Alton R. R., has been appointed assistant superintendent of motive power and machinery of the Union Pacific R. R. at Omaha, Neb.

J. P. McCuen, superintendent of motive power of the Cincinnati, New Orleans & Texas Pacific Ry., has resigned that position, effective on March 1, when he will take the rest to which he is entitled after long years of service. Mr. McCuen entered the employ of the Queen & Crescent Route as road foreman on March 1, 1882.

The master mechanics of the Atlanta, Birmingham, Knoxville and Selma divisions of the Southern Railway, have been transferred as follows: John F. Sheahan, Atlanta, Ga., transferred to Knoxville, Tenn.; J. B. Michael, Knoxville, Tenn., transferred to Selma, Ala.; G. Akans, Selma, Ala., transferred to Birmingham, Ala., and N. N. Boyden, Birmingham, Ala., transferred to Atlanta, Ga. It is reported that these changes are in accordance with a new ruling on that road which requires the transfer of all master mechanics every two years.

The New York, New Haven & Hartford R. R. has transferred master mechanics as a result of the rearrangement of divisions. The appointments and headquarters now are as follows: New York division, J. M. Collins at Harlem River; the Shore Line, P. C. Zang, at New Haven; the Providence, G. A. Moriarity, at Providence; the Boston, J. Hocking, at South Boston; Old Colony, D. R. Killinger, at Taunton; the Midland, J. B. Gannon, at East Hartford; the Western, H. C. Oviatt, at New Haven. J. McCabe, heretofore engine foreman at the Harlem River terminal, has been appointed general road foreman of engines, with headquarters at New Haven.

NOTES

Refined Iron & Steel Co.—This company announces that it has been compelled to put in a new 9 in. mill to take care of its increasing business. Its mills are located at Pittsburg, Pa.

Montreal Locomotive Works.—The Secretary of State of Canada issued Supplementary Letters Patent on Feb. 5 changing the corporate name of "The Locomotive & Machine Company of Montreal, Limited," to that of "Montreal Locomotive Works, Limited."

Rumor Denied.—The Charles G. Smith Co., 603 Park Building, Pittsburg, Pa., announces that the rumor, which has been in circulation, to the effect that since its connection with the Pittsburg Emery Wheel Company it has discontinued the machine tool business, is not true.

Roundhouse Burns.—The roundhouse and machine shops of the Central New England Railroad, at Fishkill Landing, N. Y., were destroyed by fire on February 13. In addition to the buildings there was a locomotive and a number of machine tools destroyed. The loss was about $100,000.

American Tool Works Co.—At the annual meeting of the stockholders and directors of the above company held on January 21, the following officers were elected: President, Franklin Alter; Vice-President and General Manager, J. P. Doane; Secretary, Robert S. Alter; Treasurer, Henry Luers.

Monarch Emery & Corundum Wheel Co.—Mr. Chas. A. Bacmeister has been appointed western representative of the above company, with headquarters at Chicago. Mr. Bacmeister has had an extensive experience in the grinding wheel field and his friends will no doubt be pleased to hear of his new connection.

Frost Railway Supply Company.—At a meeting of the directors of the above company, held in Detroit on Tuesday, February 11, the following officers were elected: Mr. Harry W. Frost, president; Mr. George A. Cooper, vice-president; Mr. Frederick H. Holt, treasurer; Mr. James Whittemore, secretary, and Mr. H. C. Smith, assistant secretary.

The Dearborn Drug & Chemical Works.—Mr. Robert F. Carr and several of his associates in the above company, have purchased the holdings of the estate of the late Wm. H. Edgar and at a recent meeting of the stockholders the following officers were elected: Mr. R. F. Carr, president and general manager; George R. Carr and Grant W. Spear, vice-presidents; Wm. B. McVicker, vice-president and general manager; J. D. Purcell, assistant general manager; W. A. Converse, assistant secretary and chemical director; R. R. Browning, assistant treasurer and A. E. Carpenter, superintendent.

G. Drouve Co.—At the annual meeting of the directors of the above company, held on Feb. 3, Mr. G. Drouve was elected president and treasurer, and Mr. William V. Dee secretary. Mr. Dee, who recently resigned from the staff of the *Railway Age*, has also been appointed general sales manager. This company manufactures the "anti-pluvius" sky-light, of which 125,000 sq. ft. have been installed at the Hoboken terminal of the D. L. & W. Railroad, and the Lovell window operating device, which is in use in the shops of many of the railroads, as well as the Drouve ventilators, drying stoves, etc. It will exhibit its sky-light and window operating device at the annual convention of the American Railway Engineering and Maintenance of Way Association, to be held at Chicago March 17 to 19.

Passenger Car Lighting, Canadian Pacific Railway.—The Safety Car Heating and Lighting Company has just completed the installation of 8,000 of its latest single mantel lamps in cars on the Canadian Pacific Railway. This type of mantel is capable of giving 99.5 candle power with a gas consumption of 2.12 cu. ft. per hour, which costs about one cent. These mantels have more than met the expectations of the company in regard to the length of service, as they have averaged a life of more than four months in actual srvice, while the expectation did not exceed a life of three months. In connection with this new equipment the Pintsch Compressing Company has completed the installation of plants at Vancouver, Moose Jaw and Winnipeg, Canada, and has arranged for charging facilities on the Canadian Pacific Railway at Montreal and Toronto.

CATALOGS

IN WRITING FOR THESE PLEASE MENTION THIS JOURNAL.

Lock Nuts.—Wm. Howard Co., Philadelphia Bourse, is issuing a leaflet illustrating and describing the Blanton lock nut. This nut is made in sizes to fit bolts from ¼ to 4 in. in diameter.

New Prices.—The Burke Machinery Company, Cleveland, O., is issuing a sheet of new prices of the machines manufactured by it. These include milling machines, drill presses, cut-off saws, oil forges, etc.

Vises.—The Hollands Mfg. Co., Erie, Pa., is issuing catalog A2, illustrating and describing a large variety of vises, plumbers' tools and natural gas burners. A table of sizes, capacities and prices is included with each tool.

Cast Steel Bolsters.—The Gould Coupler Company, 341 Fifth Av., New York, is issuing part catalog No. 4 illustrating and describing the "Crown" cast steel body and truck bolsters, which are designed to give a maximum strength with a minimum weight.

Valves for High Pressure.—Jenkins Brothers, 71 John St., New York, is issuing a supplement to its 1907 catalog, which supersedes pages 70 and 71 therein and gives illustration and description, as well as details of sizes and prices, of extra heavy gate valves for 150 and 250 lbs. steam pressure.

Air Compressors.—The Bury Compressor Co., Erie, Pa., is issuing two new bulletins. No. 30 contains illustrations and full description of duplex and compound air compressors either steam or belt driven in all practical sizes and capacities. No. 32 treats in a similar manner the center crank design of air compressors and vacuum pumps.

Railroad Signaling.—The Union Pacific Railroad is issuing a very attractive pamphlet containing a large number of three color views showing the automatic signals installed on that system. These pictures are accompanied by a description of the apparatus and an account of its working. A brief history of railway signaling is also given.

Instructions for Using Thermit.—The Goldschmidt Thermit Co., 90 West St., New York, is issuing a book giving full instructions for the use of thermit in repair work. This includes a list of the tools and appliances required for different classes of work and detailed explanation of the proper method of preparing the work and making the weld.

Steam and Water Specialties.—The Golden Anderson Valve Specialty Company, Fulton Building, Pittsburg, Pa., is issuing a leaflet which illustrates and describes pressure reducing valves, non-return valves, tilting steam traps, float valves, altitude valves, clean seat valves, gauge cocks and water gauges. These valves are made for serving all pressures and capacities.

Foundry Information.—The January issue of the "Obermayer Bulletin" of foundry information, published and issued by the S. Obermayer Company, Cincinnati, O., contains a number of most interesting articles on different phases of foundry practice, which are written by practical men skilled in the subject. This bulletin will be sent free to any foundryman who desires it.

Second-Hand Machinery.—The Niles-Bement-Pond Company, 111 Broadway, New York, is issuing list No. 15 of second-hand metal working machinery. This includes a brief, but complete, description of 340 different machine tools, including practically all designs and sizes of metal working tools. The present location of the machine, its weight and its general condition are included.

Belt Conveyors.—The Jeffrey Mfg. Co., Columbus, O., is issuing a booklet largely given up to illustrations of installations of rubber belt conveying machinery for handling material of various kinds. The wide range of usefulness, and the large capacity, of this type of conveyor is clearly shown in the photographs. Prices of the belts and rollers of different designs are included.

Steel Tires.—A paper read before the Western Railway Club, on October 18, 1907, by Mr. George L. Norris, on the subject of "Causes of defects and failures of steel tires," has been reprinted in a standard size booklet by the Standard Steel Works, Harrison Building, Philadelphia. This paper was a most complete presentation of the subject and included a large number of illustrations. The discussion of the paper is also included.

Calendars.—Among the calendars received for the current year the ones from the following named companies are especially noticeable: The American Wood Working Machinery Company; H. B. Underwood & Co.; Flannery Bolt Company; Bangor & Aroostook Railway Company; Hazard, Cotates & Bennett Company, and the Falls Hollow Staybolt Company. The latter is an excellent reproduction of a famous painting by Franz Charlet entitled "The First Days of Spring."

Steam Gauges and Valves.—The American Steam Gauge & Valve Mfg. Co., 208 Camden St., Boston, Mass., is issuing a new 246 page cloth bound catalog, completely illustrating and describing the large variety of gauges, valves, indicators, and kindred appliances for governing, indicating, measuring, recording and controlling steam, water, air, gas, oil, ammmonia and other pressures, manufactured by it. The information in the catalog is most complete and it should be available for reference by every one having anything to do with these appliances.

Air Brake Lubrication.—The Joseph Dixon Crucible Co., Jersey City, N. J., is issuing an attractive leaflet, printed in two colors, under the above title. The descriptive matter includes a description of the air brake testing rack at Purdue University and gives an account of tests made with Dixon flake graphite on it. Following this is a description of the value of air brake and triple valve grease and a note as to the parts of the air brake system on which it can be used to advantage. Several pages are given up to a discussion of the lubrication of air pumps.

Record No. 64.—The Baldwin Locomotive Works has recently issued a new record which includes a brief history of the Central Railroad of Brazil, and gives illustrations and complete descriptions of the large number of locomotives which have been built for that company by the Baldwin Locomotive Works. These include many types and designs for both narrow and full gauge tracks. This company has furnished altogether 296 locomotives for this road. The company, through its extra work department, also furnishes parts for repairs for all of these locomotives.

Shay Geared Locomotives.—The Lima Locomotive & Machine Company, Lima, O., is issuing one of the most attractive standard 6 x 9 in. catalogs that has come to our notice. This catalog bears the No. 151 and contains illustrations of a large number of locomotives, together with the principal dimensions and hauling capacities of both Shay geared and direct connected or rod types, built by this company. The standard specifications for construction, as well as some other useful general information is also included. This company builds logging cars as well as locomotives.

Journal Boxes.—The T. H. Symington Co., of Baltimore and Chicago, have recently published an attractive catalog, briefly worded, but illustrating very fully by half-tone cuts the various types of Symington journal boxes which it manufactures to suit different classes of service. Its now well known "torsion spring" lid is recommended for freight service and the "Pivot" lid for passenger cars and locomotive tenders. In addition attention is called to this company's ability, as specialists and experts in the line of journal box manufacture, to furnish boxes of any design desired.

"The Man Who Didn't Know When He Had Failed."—A most artistic and attractive booklet bearing the above title has been received from the Carborundum Company. It is a very interesting story by Mr. F. W. Haskell, reciting the development of the manufacture of carborundum. This substance fifteen years ago was sold by the carat and commanded a price of $880,000 a ton and the total world's output at that time was four ounces a day. From that beginning the present Carborundum Company was evolved, which has an output of ten million pounds a year. The booklet is illustrated with appropriate marginal sketches.

Longest Narrow Gauge Railway.—The Arthur Koppel Company, Machesney Building, Pittsburg, Pa., is issuing a pamphlet containing a reprint from the London *Engineering*, which describes the features of construction of the longest narrow gauge railway in the world, built by this company in German-Southwest Africa and known as the Otavi Railway. It is a most interesting piece of construction and the rolling stock as well as the bridges, yards and track work, are thoroughly illustrated and described in this article. The work was accomplished under the most difficult conditions of climate and labor and reflects great credit on this company.

Springs.—The Standard Steel Works, Harrison Building, Philadelphia, Pa., is issuing a standard size catalog on the subject of springs for steam or electric railways. It illustrates several of the more important designs of elliptical, semi-elliptical and coiled springs which are now in use on steam and electric roads; gives a brief description of the salient features of each design, and also includes views of the spring department of these works. The large capacity of the storage racks, which permits the carrying of sufficient quantities of flat and round bars to meet the heavy demands, puts this company in a position to start work immediately upon any design of springs desired without any delays occasioned by the non-arrival of bars from the steel mills.

The Weathering of Coal.—Bulletin No. 17 of the Engineering Experiment Station of the University of Illinois, which relates to the weathering of coal and the losses in fuel values which accompany storage under various conditions, has just been issued. This recounts a series of tests by S. W. Parr and N. D. Hamilton, which add materially to the information on this subject and gives a much better understanding of matters pertaining to weathering, spontaneous combustion and other difficulties which attend the storage of coal in large masses. Other bulletins being issued by the University are No. 19 on comparative tests of carbon, metallized carbon and tantalum filament lamps, and No. 16 which presents the results of several years study on trussed roofs by N. Clifford Ricker, professor of archcitecture at the University. The bulletins can be obtained upon request.

Electrical Machinery.—Among the many bulletins being issued by the General Electric Company might be mentioned bulletin No. 4559 on the subject of direct current motor starting devices. These are improved instruments and are very completely illustrated and described in this bulletin, practically any desirable design being obtainable. Also buletin No. 4564 on the subject of centrifugal air compressors. These are low pressure machines, having a rating from .88 to 4 lbs. per square inch and a capacity from 750 to 10,000 cu. ft. of free air per minute. These sets are furnished driven either by Curtis steam turbines, direct current motors or induction motors. They are for either pressure or exhauster service, being specially adapted for ventilation. Bulletin No. 4562 is on the subject of mill type motors, which are built in sizes from 30 to 150 h. p., in either direct or alternating current types. These motors are specially designed for very heavy intermittent loads; are completely enclosed and dust proof.

LOCOMOTIVE FUEL ECONOMY

"Of the one hundred million tons of coal used in the railway locomotives each year, not more than five per cent. of the heat developed is converted into the actual work of pulling trains, yet these railways must annually haul three million cars of coal to keep these locomotives moving."

The purpose of this article, or study, is to present the importance of the locomotive fuel question as forcibly as possible and to direct attention to the great possibility of savings which may be made in that direction. An attempt has been made to bring out the best practices in use, or in the process of being developed, on different railroads in connection with the various phases of this question—from the purchase of the fuel to its use on the locomotive. Where reports of experts were available as to any part of the problem, and it is a large one, they have been made use of. A study of the locomotive fuel question, no matter how complete it may be, cannot be considered as having exhausted the subject, because of the crude state of the problem and the fact that developments must surely take place, especially at a time like this when the railroads are forced to closely examine into possible economies.

Synopsis.

Importance of the Locomotive Fuel Question.

Fuel for locomotives is the largest single item of expense in the cost of conducting transportation on most of our American railroads. The table on the following page has been compiled from the annual reports of several of the larger railroad systems in different parts of the country, to give a clear idea of the importance of this item. For the nineteen roads the cost of fuel on the locomotive tender amounted to $92,492,098, or 11.42 per cent. of the total operating expenses of these roads. The next most important item in the cost of conducting transportation is the combined wages of enginemen and roundhouse employees. For the first seventeen railroads included in the table this item amounts to $67,369,934 as compared to $80,554,716, the cost of fuel. In arranging the table several large systems in each part of the country have been selected.

A study of the ratios of the cost of fuel to the total operating expenses brings out some interesting facts. The ratio is highest (from 13 to 17 per cent.) on the New England and Middle Western roads and on the Seaboard Air Line. It is lowest on the Chesapeake & Ohio (7.81), Louisville & Nashville (8.01), Pennsylvania Railroad (9.25), and Baltimore & Ohio (9.34). On the other roads it ranges between 10 and 13 per cent. On fifteen of the nineteen roads the wages of enginemen and engine house men combined is less than the cost of fuel—in some instances very much less. On the Pennsylvania Railroad these two items are about equal, while on the Baltimore & Ohio, Chesapeake & Ohio and Louisville & Nashville, the wages are higher than the cost of fuel.

It would be reasonable to suppose from the importance of the fuel item that the railroads as a whole would devote considerable attention to its inspection, handling and economical use. It is surprising, therefore, to find how little attention is given to this question and how little its importance seems to be appreciated. The fuel resources of this country are not unlimited and the cost of fuel is advancing. Reduced rates and increased cost of labor and material make it necessary for the railroads to study possible economies closely, and there seems to be no more promising field than this item of fuel—from its purchase to its use on the locomotive. Several of the railroads have recently started to take active steps in the direction of fuel economy. Most of these have concentrated their entire attention on some particular phase of the question, such as inspection, distribution, handling or use of fuel. The purpose of this article is to bring out the best practice in these different branches, or departments, and to present the whole question in as complete and logical a form as possible.

Mining and Utilization of Fuel.

By Dr. J. A. Holmes.

(At the December, 1907, meeting of the American Society of Mechanical Engineers Dr. J. A. Holmes, of the United States Geological Survey, in discussing the paper on "The Rational Utilization of Low Grade Fuels," presented by Mr. F. E. Junge, of Berlin, Germany, called attention to the investigations made by the Government dealing with wastes that are taking place in the mining and utilization of coal. The present condition of the fuel resources of this country and some of the larger wastes that are taking place, were so clearly stated that his remarks are reproduced quite fully, and are recommended for the earnest consideration of those who are interested in the fuel question.)

The investigations that have been conducted at St. Louis, at Norfolk, and at Denver, during the past three years, had for their cardinal purpose the comparison of one character of fuel with another. It was hoped—and in part only was that hope realized—that the engineering investigations would give us results even more valuable than they were; but the equipment which we were compelled to use in the beginning was selected because it represented the ordinary power plant in use in the United States, and the comparisons of the various fuels have been made on this equipment with only such slight modifications as were feasible at the time.

It has been common to find, where there is a vein eight feet in thickness, that two or three feet is left unmined and is permanently lost, because of the subsequent caving in of the mine. We have found, furthermore, that there is no sharp line drawn between high grade and low grade fuels; that in certain mines the amount of coal left unmined, under the ground, exceeded 75 per cent. of the total available coal, and the average result is

ITEMS OF INTEREST TO MECHANICAL DEPARTMENT OFFICIALS, TAKEN FROM THE ANNUAL REPORTS OF A NUMBER OF RAILROADS, AND SHOWING FORCIBLY THE IMPORTANCE OF THE ITEM "FUEL FOR LOCOMOTIVES."

NAME OF ROAD.	Boston and Maine.	N.Y.,N.H. & H. RR.[4]	N.Y.C. & H. R.R.	Erie.	P. R.R.	B. & O. R.R.	C. & O.	Seaboard	So. Ry. Co.	L. & N. R.R. Co.
Annual report—year ending	6-30-07	6-30-07	12-31-06	6-30-07	12-31-06	6-30-07	6-30-07	6-30-07	6-30-07	6-30-07
Mileage operated	2,288	2060.1	3783.9	2168.8	3819.68	4006.3	1827.4	2610.9	7546.8	4306.3
Gross earnings from operation	41,125,256	55,601,936	92,089,768	51,194,113	148,239,882	82,243,921	25,796,860	16,427,942	56,657,994	48,263,945
Expenses—operating[1]	30,968,397	37,850,081	64,953,695	33,579,958	101,805,644[6]	54,880,090	16,650,306	12,948,041	43,068,547	35,781,302
Net earnings from operation	10,156,859	17,751,854	27,136,073	17,614,155	46,434,238	27,363,830	9,146,554	3,479,900	13,589,447	12,482,642
Ratio expense to earnings	75.3	68.07	70.53	65.60	68.68	66.73	64.54	78.82	76.01	74.17
Operating expenses: Main. of way and structures	4,905,226	5,479,089	10,718,599	5,087,974	17,060,498	10,542,498	3,090,037	2,205,997	7,660,168	8,065,898
Per cent. of total expense	15.81	14.48	16.50	15.15	16.75	19.21	18.56	17.04	17.79	22.54
Maintenance of equipment	4,305,913[3]	5,638,784	14,569,057	8,147,536	26,201,244	13,448,502	4,721,345	2,314,914	9,576,041	8,709,610
Per cent. of total expense	13.90	14.89	22.43	24.25	25.73	24.50	28.35	17.88	22.23	24.34
Conducting transportation[1]	20,830,959	25,286,306	37,267,589	9,075,407	55,276,180	29,380,155	8,437,507	7,827,312	23,941,599	17,972,347
Per cent. of total expense	67.26	66.81	57.38	56.83	54.29	53.54	50.68	60.45	55.59	50.23
General expense	926,296	1,445,902	2,398,449	1,269,039	2,835,334	1,508,934	401,415	599,816	1,890,739	1,033,445
Per cent. of total expense	3.00	3.82	3.69	3.77	2.78	2.75	2.41	4.63	4.39	2.88
Maintenance of equipment expen's in detail: Superintendence	129,298	155,926	297,691	286,653	776,631	260,552	89,623	68,918	181,144	203,688
Locos., repairs & renewals	1,367,598	2,264,160	5,587,769	3,170,627	8,585,298	4,653,638	1,320,110	852,908	3,504,922	2,757,091
Cars, pass., rep. and ren.	729,935	1,139,476	1,767,055	670,801	2,308,239	966,328	314,051	276,217	814,678	565,016
Cars, freight, rep. and ren.	1,040,332	1,243,481	5,347,237	3,574,031	12,290,906	6,586,610	2,741,990	710,667	4,549,030	3,578,067
Cars, work, rep. and ren.	35,978	34,231	90,512	54,615	263,831	152,451	24,904	39,313	75,710	76,762
Floating equipment	4,172	185,481	416,598		449,120	215,474	15,202	4,220	20	
Tools and mchy., repairs	56,835	183,960	437,337	259,732	771,013	355,263	127,122	84,501	286,393	198,274
Other expenses	200,093	432,065	624,855	120,408	756,203	258,183	88,340	123,167	164,141	228,558
Injuries to persons				10,667						20,547
Improve., new equip., etc								155,000		1,081,604
Conducting trans. items of interest to mech. dept.: Engine house men	3,031,318	3,309,225	1,069,719	958,561	1,838,204	916,336	300,035	115,137	4,002,000	614,641
Engine men			5,117,517	2,854,398	7,599,581	4,976,562	1,478,010	887,996		2,667,403
Fuel for locomotives[2]	5,269,823	5,322,325	6,875,590	4,329,168	9,418,285	5,124,445	1,301,155	1,896,288	4,717,681	2,866,037
Locos., water supply	184,727	316,512	438,556	212,565	777,049	324,517	132,729	77,489	294,905	184,345
" stores for					304,900	249,320	79,938	69,460		
" other supplies	123,633	187,551	425,868	246,399	410,218	185,181	60,255		224,031	245,838
Ratio fuel to opera'g exp	17.01	14.06	10.58	12.89	9.25	9.34	7.81	14.64	10.95	8.01
Locos., number	1,073	1,176	2,075	1,384	3,215	1,837	670	398	1,536	865
" tractive power				43,490,311	94,880,283	57,169,677				
" mileage	32,647,960		68,200,265	34,437,505	96,099,303	64,244,352	18,742,322	12,507,308	46,460,363	
" Cost per mile in cents	31.21			34.31		25.6	23.23	31.44	28.09	
Average cost of fuel per ton			1.70					2.60		
Cars, passenger, number	1,719	2,202	2,243	1,096	2,072	1,078	301	333	995	559
" freight "	20,782	19,776	69,070	51,514	119,036	78,704	31,593	12,411	56,225	39,528
" service "	537	1,056	3,220	1,955	3,526	2,707		615	1,292	1,452

NAME OF ROAD.	Wabash.	L. S. & M. S. Ry.	C. M. & St. P.	C.& N.W.	C. R. I. & P.	Missouri Pacific.	A. T. & S. F. Ry.	Union Pac.	So. Pac. Co.[7]
Annual report—year ending	6-30-07	12-31-06	6-30-07	6-30-07	6-30-07	6-30-07	6-30-07	6-30-07	6-30-07
Mileage operated	2514.3	1520.3	7049.4	7550.6	7780.2	6375.1	9273.1	5644.5	9400.5
Gross earnings from operation	27,432,473	42,544,378	60,548,554	68,878,931	60,238,419	48,703,342	93,683,406	75,651,105	117,331,812
Expenses—operating[1]	19,505,147	27,252,077	39,400,410[6]	44,789,025	41,044,142	32,515,070	58,867,901	40,155,522	73,631,374
Net earnings from operation	7,927,326	9,868,577	21,148,144	24,089,906	19,194,277	16,188,272	34,815,505	35,495,583	43,700,438
Ratio expense to earnings	71.10	64.06	65.07	65.03	68.13	66.76	62.84	53.08	62.75
Operating expenses: Main. of way and structures	2,747,667	5,322,562	5,830,967	8,904,940	8,754,396	5,906,120	15,286,062	10,066,868	16,031,877
Per cent. of total expense	14.08	19.53	14.80	19.88	21.33	18.16	25.96	25.07	21.77
Maintenance of equipment	3,915,261	5,843,734	8,589,757	8,713,026	7,184,128	6,998,863	11,779,846	7,853,933	15,017,190
Per cent. of total expense	20.07	21.44	21.80	19.46	17.50	21.52	20.01	19.55	20.39
Conducting transportation[1]	12,153,324	15,376,192	22,782,468	25,990,596	23,420,948	17,595,101	29,538,964	20,276,530	39,238,101
Per cent. of total expense	62.31	56.42	57.82	58.03	57.07	54.11	50.18	50.50	53.29
General expense	688,894	709,588	1,250,349	1,180,461	1,684,668	2,014,985	2,263,027	1,958,191	3,344,204
Per cent. of total expense	3.53	2.60	3.17	2.63	4.10	6.20	3.84	4.88	4.54
Maintenance of equipment expen's in detail: Superintendence	102,265	175,512	100,884	178,994	279,729	234,699	599,290	751,962[8]	1,069,770[8]
Locos., repairs & renewals	1,520,346	1,756,427	2,590,947	2,394,785	3,171,376	3,212,112	4,697,673	2,779,348	5,989,492
Cars, pass., rep. and ren.	271,693	613,374	832,390	622,669	740,244	516,776	941,486	697,473	1,503,692
Cars, freight, rep. and ren.	1,120,557	2,693,946	4,505,838	4,830,198	2,431,538	2,533,328	4,415,645	3,129,943	4,934,229
Cars, work, rep. and ren.	21,238	106,877	73,367	85,878	152,034	106,375	136,700	139,330	345,356
Floating equipment	17,972	7,007		1,198	2,772	25,479	23,572		536,454
Tools and mchy., repairs	128,122	201,599	224,920	194,617	225,888	284,923	315,844	355,875	638,193
Other expenses	197,451	288,990	253,934	365,231	132,542	83,218	649,582		
Injuries to persons				39,452	48,002	11,706			
Improve., new equip., etc	535,613								
Conducting trans. items of interest to mech. dept.: Engine house men	1,951,866	422,091	4,064,235	939,257	3,915,181	738,208	895,517	3,833,238[9]	7,458,589[9]
Engine men		2,033,532		3,940,753		2,531,932	4,200,719		
Fuel for locomotives[2]	2,272,041	3,089,422	5,325,673	6,218,724	6,013,600	3,782,688	6,123,504	5,169,701	7,375,948
Locos., water supply	117,627	190,783	215,273	302,456	338,701	236,410	596,513		
" stores for									
" other supplies	104,764	168,072	207,572	272,847	317,265	247,594	393,108		
Ratio fuel to opera'g exp	11.64	11.33	13.51	13.88	14.65	11.63	10.40	12.87	10.01
Locos., number	622	821	1,017	1,422	1,343	1,068	1,791	1,051	1,759
" tractive power	14,170,797				33,058,752	28,862,350	52,341,975		
" mileage	22,769,821	28,095,159			41,141,517		51,570,692	32,357,330	57,488,094
" Cost per mile in cents	24.84	26.63			34.48		33.14	37.44	37.25
Average cost of fuel per ton	1.41	1.66			2.188		1.61		2.91
Cars, passenger, number	441	614	1,089	1,311	878	693	1,135	643	1,707
" freight "	24,401	35,586	44,626	58,637	41,261	37,318	49,991	25,377	43,757
" service "		1,468	222		2,956	4,811		2,929	4,517

[1] Not including taxes. [2] Including operation of fuel stations. [3] Includes $741,668 for new equipments. [4] Steam lines only. [5] Includes Delaware and Raritan Canal. [6] Includes $946,867 for additions to property. [7] Rail lines only. [8] Superintendence and other expenses. [9] Locomotive service other than fuel.

As far as possible, several roads have been selected from each section of the country. Statistics of this kind are of use for general comparisons only, since the methods of accounting, in force on the different roads when the annual reports, from which these figures were taken, were compiled, differed more or less. Under section 20 of the act to regulate commerce the Interstate Commerce Commission has provided a standard system, or classification, for accounting for the use of the railroads. This went into effect July 1, 1907. Statistics compiled in accordance with this act, when they are available, will prove of great value for the purposes of comparison.

The cost of the locomotive per mile run is taken directly from the reports and includes the cost of fuel, oil and supplies, wages of engineers, firemen and wipers, and repairs and renewals.

In 1906 400,000,000 tons of coal were mined in the United States. During the same period the railroads used about 100,000,000 tons of coal for locomotive fuel, or 25% of the total output.

that at least 50 per cent. of the possible coal supply in these veins is left under the ground and unrecoverable. I recall one case in particular in which out of a possible 25-foot vein of coal, only four feet were taken out, because of unskillfulness in mining, and the rest left underground and practically destroyed. The carelessness with which coal miners have gone to work mining the lower seams and allowing cave-ins to follow, has had the result of leaving the coal in the higher seams unmined and practically lost because of the caving-in of the adjacent material. In West Virginia, and in Ohio, and in various other places, the cost of mining has been greatly increased, entirely out of proportion to the amount of coal that has been mined, because of this carelessness.

I desire to call attention to the possibility of utilizing these coals by the location of plants at the mines, thus avoiding the cost of transportation. Consider a single illustration. Take the Pennsylvania Railroad, which uses 40,000 tons of coal every day in its own locomotives. If, as is now being attempted, all of that power can be generated from low grade fuels not now utilized at all, we shall see an enormous gain in the direction of a solution of our fuel problems and our problem of transportation would be vastly simplified. Consider for a moment what the application of this same thought would mean to the 100,000,000 tons of coal now annually consumed in our locomotives.

Very few persons realize that so rapidly is the fuel industry developing that during each succeeding decade for the past eighty-five years the amount of coal mined and used in the United States has equaled that of all the preceding decades; so that the amount of coal mined and used between 1895 and 1905, was equal to that mined and used during the preceding seventy-five years. Now, there has not been a corresponding increase in efficiency, nor has there been any marked gain in the utilization of the low grade materials. What we are doing at the present time is skimming the surface, using the high grade coals and leaving the low grade coals—using the surface coals and leaving the deeper coals. Therefore, we are approaching a condition where our coal cost will be greatly increased and the amount of available high grade coal very much diminished. I am not now prepared to say when that time will come, but we trust that our coal supply will last as long as that of any other country; still we must awaken to the fact that our high grade coals are passing so rapidly, that coal lands used for supplying coke and for other special purposes, in Maryland and in West Virginia, cannot be purchased in many sections for less than $1,500 to $2,000 an acre.

I may say, in conclusion, that while these investigations have been in part under the supervision of this and the allied engineering societies, the President of the United States has, in his message to Congress, recommended the establishment by the Government of a special bureau for mining and engineering investigation, in which the work initiated at St. Louis in a crude way may be placed upon the highest possible plane as to equipment and mining and engineering data. It is proposed, furthermore, that this new bureau shall be independent, and shall be placed entirely under the supervision of the representatives of national engineering societies and other allied bodies, who, together with those chiefs of Government bureaus who have to do with actual construction work, shall direct the energies of the department.

Government Fuel Investigations.

A brief statement of the purposes of the Government fuel investigation and what has thus far been accomplished may be of interest in connection with Dr. Holmes' remarks.

The purposes of these investigations are:

To lessen the waste of the nation's fuel supply by showing how fuels can be mined and used more efficiently.

To extend the nation's supply of fuel, and lessen the transportation cost by indicating how lignite, peat and other materials, now little used, may become locally valuable as fuels in portions of the country having no ordinary coal.

To find how to prevent the spontaneous combustion of coals in storage, on ships, naval stations, at the mines, etc.

To remedy the loss sustained in the production of fine coal in mining through slacking, etc.

To demonstrate the saving of by-products now wasted in the manufacture of coke, which if completely saved would be worth at present prices more than $50,000,000 yearly, and prevent large imports of such by-products.

The present waste of fuel:

Approximately 50 per cent. of the possible coal supply is now lost by being left underground or wasted before reaching the furnace.

Of many Mississippi Valley and western coals from 30 to 50 per cent of the total product mined comes out in the form of "slack" which is often sold at less than cost, or accumulates and is burned about the mines.

Of the fine portion of these Mississippi and western coals put into furnaces often 10 to 25 per cent. is unconsumed and lost in the ashes.

Of all the coal actually burned only about 5 per cent. of the heat units are actually converted into work.

In the coking of 40,000,000 tons of coal yearly, there are now wasted ammonium sulphate enough to fertilize our crops; creosote enough to preserve our timbers; pitch and tar enough to roof our houses and briquette our slack or waste coals.

Some benefits resulting from this work. It has demonstrated:

The possibility of utilizing for power purposes the large and undeveloped areas of lignite and low grade coals of the west and southwest.

The practicability of using in gas producers, for power purposes, ordinary bituminous coals and lignites, and of thus obtaining from each ton of coal more than 2½ times as much power as is obtainable in ordinary steam power plants.

The possibility of making coke from a number of coals not considered generally as coking coals.

Some of these results are not only new, but were believed to be impracticable when these investigations were begun. These and other results are worth to the country many hundred times the total cost of this work.

The Grade of Fuel to Use in Locomotives.

One of the most important considerations in connection with the question of fuel economy is the selection of the proper grade of fuel. It must be fairly uniform in quality or it will be impossible to use it economically. A front end arrangement, or grates suitable for one grade of coal, may be entirely unsuited for another and the fireman cannot obtain good results where the grade of fuel is constantly changing.

Ordinarily it is not possible for the railroads to secure a run of mine coal. A 5 or 6 in. screen is used at most of the mines and the larger coal is used for commercial purposes. The mines can usually insist on this because the railroads can secure a long haul on the superior grade of coal. On the other hand the mine operators are anxious to make contracts with the railroad company to insure keeping the mines in operation during the summer months when the commercial requirements are light. During the dull period the work is usually confined largely to the making of headings and the opening of new rooms and in getting things in shape to be pushed when the heavy demand comes. The railroads thus often secure a better grade of coal during the summer months than during the remaining part of the year. While there are instances where it might be in the interests of economical locomotive performance to confine the buying of coal to certain mines, yet the development of the district and the building up of traffic along a certain part of the line might make it advisable to secure coal from other mines. While the railroads usually do not get the best grade of coal, they pay less for it. Roughly, the mine operators get from 10 to 40 per cent. more for commercial coal than for railroad coal.

While the above considerations are important they should not be allowed to overshadow the desirability and importance of

buying the coal on a heat value basis. There is a great difference in the heat value of different coals, and while the subject has been given very little attention by most of the railroads, it is of prime importance. It is of interest to note that as a result of coal tests made at St. Louis by the United States Geological Survey, the Government is purchasing coal for about forty departmental buildings in Washington, and for public buildings throughout the country on a simple specification, the prime elements in which fix the amount of ash and moisture in anthracite at seven per cent. Premiums are paid for any decrease in the ash content up to two per cent. above the standard, and corresponding penalties are fixed for any increase in ash above the standard. Better and more complete specifications, but more difficult for the dealer to fulfil, have been fixed by a few of the largest manufacturing and power concerns of the country, in which penalty and premium are paid not only on account of ash and moisture content, but also on the basis of the British thermal units as specified in the contract.

It is possible, on a railroad, to make simple evaporative tests in actual service by which the comparative heat values of the different coals may be determined. These results will enable the railroads to place their coal contracts to the best advantage. The extent to which the heat value should govern in the purchase of the coal is considered in the section on "Distribution."

M. N. Forney, in an article in this Journal, in June, 1901, had this to say concerning the most economical coal to use on a railroad: "If, through an accident, an employee or passenger should have his toes cut off and should make a claim for damages, the most skilful legal counsel and expert testimony would be devoted to the defense of the company, and to resisting the payment of the value of the lost toes; but the cases in which railroad managers have been willing to pay anything at all to an expert to tell them how they could save a hundred or a thousand times the amount of his fees, by indicating which was the most economical coal to use, are very few. One reason for this, in some cases, is that the award of contracts for supplying coal is decided with loaded dice, and contracts are given to parties who have 'influence' at headquarters. However that may be, it is certain that it would be immensely profitable to almost any railroad company to give thorough and intelligent investigation to the quality of fuel used on its line."

Fuel Tests.

In determining the heat value of the different grades of coal used on the railroad, evaporation tests should be made on a locomotive in preference to laboratory calorimeter tests. The actual burning of the coal in large quantities under service conditions may be attended by features which would make it impossible to obtain the full value of the heat units, as shown by the calorimeter tests. More reliance would also be placed on an actual test of 100 or more tons of coal, as compared to 6 to 20 one-gram samples taken from 200 or 300 lbs. of coal.

A practical and successful method of making locomotive evaporation tests may best be explained by quoting from a paper on "The Influence of Heat Value and Distribution on Railway Fuel Cost," presented before the Western Railway Club in November, 1907, by J. G. Crawford, fuel engineer of the Chicago, Burlington & Quincy Railroad.

"The coals should be tested in groups, and in order that different groups of coals may be compared, even though the tests are made 1,500 miles apart, each group of tests, as well as the individual tests, should be carried on under similar conditions. The unit of comparison for coals is the number of pounds of equivalent water evaporated per pound of coal. It is evident that the following items will affect this ratio or unit of comparison: Kind of coal; class of engine; condition of engine; engine crew, especially the fireman; class of service. Since the object of coal tests is to determine the comparative value of various coals, all of the above conditions should be kept as uniform as possible. These items will be referred to below.

Selection of Division for Tests.—"Coals should be tested on a division where they are being used, as the firemen are already accustomed to them. When coals which differ materially from those habitually used are to be tested, a number of trial runs must be made until the firemen can properly fire the coal.

Class of Engine.—"If possible all the tests made on one railroad system should be made on one class of engine. This is advisable in order that the coals tested at one end of the system can be compared with those tested at the other end without having to correct for the difference in evaporative efficiencies of the engines.

Condition of Engine.—"Engines should always be in good condition, and this applies especially to condition of flues and firebox. Whether a brick arch is used or not, the conditions in this particular should be the same in all tests.

Engine Crews.—"During a series of tests the same firemen should be used throughout, thus avoiding any difference on this account. It is not so important that the same engineers be used, for while one engineer may use more steam than the other, the ratio of the coal to the water used will not change materially.

Class of Service.—"Passenger is preferable to freight service on account of the more uniform conditions. It is desirable that the time between terminals, the time using steam and the weight of the trains shall be nearly uniform from day to day, and that the average of these values for all tests made with each kind of coal shall be nearly the same. When tests are conducted in freight service at least twice the length of time will be required to test one kind of coal, and the expense will be more than doubled on account of additional coal weighers being required.

Organization of Test Party.—"At each terminal a fuel tester is located to take charge of the supply and weighing of the test coal and to see that none of the weighed coal on the engine is used during its stay at the terminal. The coal weigher is relieved by an engine observer before the engine leaves the roundhouse, and he stays with the engine until relieved by the coal weigher at the other terminal. The engine observer keeps record of coal, water, steam pressures, stops, shut-offs, etc., in a printed thumb-indexed note book made up of seven printed forms and three blank pages. The note book and details of the individual pages are shown in Fig. 1. From four to eight men are required to make the tests properly, according to whether one or two engines are used and whether they are single or double crewed.

Number of Tests.—"Exclusive of that used for firing up, about 150 tons of each kind of coal should be used on the tests. From six to eight round trips should be made with each coal, and where two firemen are used half the tests should be made with each fireman. This is necessary, as one fireman might be slightly better than the other. Tests in one direction on account of grades, speed or number of cars may be more favorable than in the other, hence the same number of trips in each direction are necessary.

Results.—"The data taken for each test are recorded on blanks, shown in Fig. 1, and the more important totals and averages recorded on the final result sheet of which Fig. 2 is a reproduction. The data and computations of each test are recorded in a column and the average for all tests in the average column. In a series of tests which have all been conducted under similar conditions, the heat value of each coal is proportional to the average of items No. 35 which shows the equivalent number of pounds of water evaporated from and at 212 degrees per pound of coal."

While the above tests are possibly more elaborate than some of the smaller roads would care to undertake, results of considerable value may be obtained from tests made by one or two men. It is essential, however, that the firemen be familiar with each coal before the test trips are made and that several test trips be run with each coal in order to secure fair average results.

By testing the coal in passenger service the tests may be made in from one-third to one-half the time required in freight service, and there is no reason why the tests should in any way delay the passenger trains. The difference in the kind of service should not affect the comparative efficiency of the coals to any great extent, but all of the tests should, of course, be made in the same class of service.

COAL

WEIGHT OF TENDER
- AT START (AT SCALES)
  - LOADED ______ #
  - EMPTY ______ #
- (A) IN PIT AT START ______ #
- AT FINISH (AT SCALES)
  - LOADED ______ #
  - EMPTY ______ #
- (B) IN PIT AT FINISH ______ #

CHARGE TO TRIP

(A) MINUS (B) ______ #

SACKED COAL ______ #

LOOSE COAL AHEAD OF GATE ______ #

CORRECTION ACCOUNT OF WATER LEAKING FROM TANK BETWEEN "EMPTY" AND "LOADED" WEIGHINGS AT START ______ #

TOTAL CHARGES ______ #

CREDIT TO TRIP

COAL USED FROM PIT BEFORE STARTING ______ #

COAL SAMPLE ______ #

COAL FELL OFF TENDER ______ #

COAL USED FROM PIT AFTER ARRIVING AT DEPOT AND BEFORE WEIGHING ______ #

CORRECTION ACCOUNT OF WATER LEAKING FROM TANK BETWEEN "LOADED" AND "EMPTY" WEIGHINGS AT FINISH ______ #

TOTAL CREDITS ______ #

NET COAL USED ______ #

LEAKAGE OF WATER BETWEEN WEIGHINGS

	EMPTY	LOADED	TANK LEAKAGE PER MINUTE
START			
FINISH			

NOTES: SACKS WEIGH ______ # EACH

IN ESTIMATES USE WEIGHT OF A SHOVEL-FULL ______ #

FIRE HAD ABOUT ______ # MORE / LESS COAL AT FINISH THAN AT START

COAL FROM CAR ______ KIND ______

STEAM PRESSURES

___ M.	___ M.	___ M.
00	00	00
10	10	10
20	20	20
30	30	30
40	40	40
50	50	50
00	00	00
10	10	10
20	20	20
30	30	30
40	40	40
50	50	50
00	00	00
10	10	10
20	20	20
30	30	30
40	40	40
50	50	50

	OBSERVED	CORRECTED	ABSOLUTE
AVERAGE	#	#	#
MAXIMUM	#	#	
MINIMUM	#	#	

WATER WASTES

INJECTORS	LOSS PER APPLICATION	NO. OF APPLICATIONS	TOTAL WASTES
RIGHT	#		#
LEFT	#		#

LEAKAGES	RATE PER MINUTE	NO OF MINUTES	
TANK HOSE	#		#
" "	#		#
TANK	#		#
"	#		#
MUD RING	#		#
" "	#		#
HOT BEARINGS			
	#		#
	#		#
OTHER WASTES			
	#		#
	#		#
		TOTAL WASTES	#

RECORD OF INJECTOR APPLICATIONS

RIGHT ______

LEFT ______

SHUT-OFFS

PLACE	MINUTES	REMARKS

TIME IN MOTION ______ HRS. ______ MIN

" " SHUT-OFF ______ HRS ______ MIN

" " USING STEAM ______ HRS. ______ MIN.

STOPS

PLACE	ARV.	LV.	LENGTH OF STOP	REMARKS

TIME ON ROAD ______ HRS. ______ MIN.

" OF STOPS ______ HRS. ______ MIN.

" IN MOTION ______ HRS. ______ MIN.

NO. OF STOPS ______

GENERAL

TRAIN ______ ENGINE ______ DATE ______

ENGINEER ______ FIREMAN ______

CARS

NUMBER	FROM	TO

WEATHER

	START	FINISH	AVERAGE
TEMPERATURE OF AIR			
BAROMETER—INCHES			
" —POUNDS			

RAIN OR SNOW

FROM	TO	HEAVY OR LIGHT

MISCELLANEOUS

ASH PAN DUMPED	FIRE CLEANED	GRATES SHAKEN

HAS ENGINE A BRICK ARCH? ______

SIZE OF EXHAUST TIP? ______

COAL SAMPLE IN CAN # ______ TO ENG'R TESTS

REPORT OF COAL SACKS

	LOADED	EMPTY	TOTAL
ON ENGINE AT START			
" " " FINISH			
ON HAND AT N. or E. TERM			
" " " W or S. "			

	PLACE	SIGNATURE
COAL WEIGHER		
" "		
ENGINE RIDER		

WATER RECORD

PLACE	TEMP.	INCHES	WT. LBS.	AMT. DRAWN

AVERAGE ______ °

TOTAL - - - - - - - - ______ #

CORRECTIONS

WATER WASTED ______ #

WATER IN GAUGE GLASS ______ #

TOTAL - - - - - - ______ #

WATER APPARENTLY EVAPORATED ______ #

NOTE. WATER AT END OF RUN WAS ______ INCHES {HIGHER / LOWER} IN GLASS THAN AT START.

FIG. I.—BLANKS FOR RECORDING OBSERVATIONS OF LOCOMOTIVE FUEL TESTS.

Inspection at the Mines.

Fuel for locomotives is the largest single item in the cost of conducting transportation, except on some of the eastern roads, where the item of wages for enginemen runs as high and in some instances slightly higher. On a large railroad the inspection branch of the mechanical department cost last year 1½ per cent. of the value of all the material used in that department, subject to inspection. The coal inspection for the same time cost only one-twelfth of one per cent. of the fuel bill.

There is no question but that the possibilities of saving due to a careful inspection of fuel are very great, and yet few of the roads have taken any important steps in this direction.

Under present conditions the mines are, in many instances, able to unload a lot of undesirable and oft-times worthless coal on the railroads simply because they know it will not be detected until it gets to the fireman, and then, although he may complain, there is no one whose business it is to follow the matter up. The inspection of fuel should be placed in the hands of some person or department. A sufficient force of inspectors should be provided to watch the output of each mine closely. If there is any question as to change in the grade of coal, as concerns its heat value, it may be checked roughly by laboratory calorimeter tests, which are simple and inexpensive.

Under present conditions most roads have no way of detecting whether the proper size screens, or any screens at all, are used at the mines and often a large amount of slate and rock is included, which is not only worthless but interferes greatly with the performance of the locomotive. Another important feature is that the weights should be checked and precautions taken to make sure that the scales at the coal tipples are accurate and in good condition. Another fruitful source of economy is to see that each one of the coal cars is loaded to its capacity, and so loaded that the coal will not be lost off in transit. A complaint was made in a certain district last year, during the time of car shortage, that the mines were short 70 or 80 cars a day. Investigation showed that to each loaded car could be added from one to four tons. A little attention to this matter resulted in a considerable improvement.

Distribution.

On the larger railroad systems, where there are several sources of supply, the problem of buying and distributing the coal to the best advantage is a serious one. Ordinarily this question is not given the thought and attention which it should have, but is decided for reasons which seem important but which do not prove to be the most important ones when the question is given more careful study. An ideal and practical method of controlling the distribution to the different coaling stations was presented by J. G. Crawford, fuel engineer of the C., B. & Q., in the paper which he presented before the November, 1907, meeting of the Western Railway Club. The idea is simple, and is based on good hard, common sense. Certain traffic conditions may arise which will make it necessary, or advisable at times, to temporarily interfere with such a system of distribution and the general plan may have to be modified because of certain traffic conditions; the fuel department should, of course, keep in close touch with the car service and traffic conditions.

ITEM	TEST NUMBER				AVERAGE	EXPLANATIONS
1	TRAIN					
2	DATE					
3	ENGINE					
4	ENGINEER					
5	FIREMAN					
6	WEATHER		Rain			
7			Temperature			
8	ACTUAL TIME TABLE		Leave or Arrive			
9			Arrive or Leave			
10	TIME		On road			
11			Of stops			
12			In motion			Item 10 – Item 11
13			Shut off while in motion			
14			Using steam			Item 12 – Item 13
15	NUMBER OF STOPS					
16	" " CARS					
17	AV. SPEED M.P.H.		In motion			÷ Item 12
18			Between terminals			÷ Item 10
19	BOILER PRESSURE WHILE USING STEAM		Average			
20			Minimum			
21	FACTOR OF EVAPORATION, QUALITY ASSUMED 98.5%					[illegible] (See Kent)
22	COAL	ANALYSIS	Moisture %			
23			Volatile Matter %			
24			Fixed Carbon %			
25			Ash %			
26			Sulphur %			
27			British Thermal Units by Parr Calorimeter			
28		CONSUMPTION ACTUAL	Total			
29			Per hour			Item 28 ÷ Item 14
30			" " per sq. ft. of G. S.			Item 29 ÷ Grate surface
31	WATER		Apparently evaporated			Water entering boiler
32			Equivalent Evaporation, from and at 212°			Item 31 × Item 21
33			Temperature			Thermometer in manhole
34	EVAPORATION	PER POUND OF COAL, ACTUAL	Apparent			Item 31 ÷ Item 28
35			Equivalent			" 32 ÷ " 28
36		RATE PER HR.	APPARENT			" 31 ÷ " 14
37			EQUIVALENT	Total		" 32 ÷ " 14
38				Per sq. ft. H. S. (Inside Flues)		" 37 ÷ Heating surface
39	COMMERCIAL BOILER HORSEPOWER					" 37 ÷ 34.5

17-COLUMNS BETWEEN ARROW POINTS FOR TEST RECORDS

LESS IMPORTANT AVERAGE RESULTS

COAL	CONSUMPTION	TOTAL	Dry	
			Combustible	
		PER HR.	Dry	
			Combustible	
EVAPORATION	APPARENT	PER LB. COAL	Dry	
			Combustible	
	EQUIVALENT		Dry	
			Combustible	
			Actual, by Parr Calorimeter	
Heating surface per Boiler H.P.				
Boiler efficiency				

ENGINE DATA

Engine number		
" class		
Heating surface, inside flues		
Grate "		
Exhaust tip, diameter		
" ", bridge		

HELPER USED

TEST	FROM	TO

KIND OF COAL

Name	
State	
County	
Town	
Mine	
Grade	
Mined by	
Purchased of	
Tested between	

C. B. & Q. R. R. Co.
OFFICE FUEL ENGINEER
COAL TESTS
CHICAGO, ILL.
NO.

FIG. 2.—SUMMARY SHEET FOR RESULTS OF LOCOMOTIVE FUEL TESTS.

Because of the importance of Mr. Crawford's paper and the fact that the system advocated by him is eminently practical as a basis upon which to work, that portion of the paper which refers to the distribution of fuel is reproduced complete. The paper was thoroughly discussed at the meeting and the foot notes, which are used, refer to facts which were brought out in connection with the discussion. The advantages of this system of distribution are the possible reduction in the cost of fuel, the improvement which may be made in locomotive service by supplying a uniform grade of coal over a division and the increased earning capacity of the coal cars. For convenience Mr. Crawford has assumed a hypothetical case—a railroad known as the A. B. C. R. R. System. The first step would be to test the different coals which were available and the following results are assumed to have been obtained:

Name of Coal.	Equivalent Evaporation per Pound of Coal, Actual.	Rank.	Price per Ton.
A	5.60	80.0%	$1.50
B	5.60	80.0	1.30
C	6.30	90.0	1.30
D	6.30	90.0	1.60
E	7.00	100.0	1.30
F	7.00	100.0	1.10
G	7.70	110.0	1.40
H	7.70	110.0	1.20
I	8.40	120.0	2.10
J	8.40	120.0	2.50

"The above coals do not necessarily represent individual companies or mines, but coals of equal heat value and price from the same point of distribution are included under one name. For convenience the coals have been assumed to be poorer and better than the standard coal by multiples of 10 per cent. The prices selected in most cases bear little or no relation to the heat value, which is true under actual conditions.

Coal Distribution, A. B. C. Railroad.—"For convenience the A. B. C. Railroad System, as shown in Fig. 10, has been assumed as having the following requirements and conditions:

Coaling stations require respectively the equivalent of 100, 200 and 300 tons of standard (100 per cent.) coal per day.

That the railroad can get as much coal as it desires from all the sources of supply.

That all these coals will mix with each other without additional trouble from clinkering, etc.*

Cost of handling at chutes, ten cents † per ton.

Cost of haulage from source of supply to chute, two mills per ton mile.‡ (Under the accounting system put in force by the Interstate Commerce Commission on July 1st no charge is made against the fuel account for the haulage of coal on a company's own line. This has been the practice, at least on the more important lines, for a number of years past; although about 1901 at least two of the important systems charged their fuel account with the haulage of company coal at the rates of three and five mills per ton mile, respectively. Whether or not the haulage of company coal on a company's own line is, or is not, charged to the fuel account, is a matter of no importance, as the cost remains the same in either case, but in order to work out the best coal distribution it is a matter of the utmost importance to know accurately this cost of haulage. The above rate of two mills per ton mile is probably too low in most cases, but is selected at this figure to simplify the computations to follow.

Competitive Points.—"The price and heat values of the coals have been so selected that they illustrate a number of combinations that arise in practice which will be taken up under the following headings:

Equal Heat Value, Unequal Price and Same Source of Supply.—"Coals G and H having the same heat value, and being supplied from the same points should cost the same. As $1.40 per ton is asked for G and $1.20 for H, G should not be used, and thus is eliminated from consideration.

Equal Heat Values, Unequal Price and Different Sources of Supply.—"Coals J and I, Fig. 4, have the same heat value and J is supplied at $2.50 per ton from a station No. 4, 300 miles from station No. 43, where I is supplied at $2.10 per ton. The dividing line between coals J and I, which is called the competitive point, is found from the following equation in which X is the distance from station No. 4 to the competitive point:

$$\frac{\$2.50 + \$\ .10 + x\ (\$.002)}{120\%} = \frac{\$2.10 + \$\ .10 + (300 - x)\ \$.002}{120\%}$$

$$x = 50 \text{ miles}$$

This shows that at all points north of station No. 38, J coal should be used; south of station No. 38, I coal should be used,

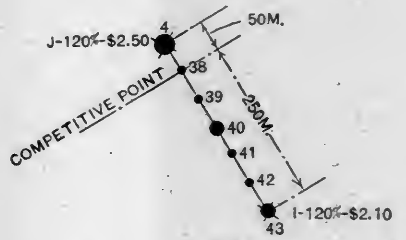


Fig.4

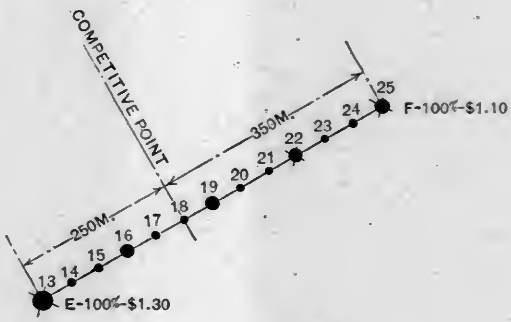


Fig.5

and at station No. 38 either I or J coal can be used, as both will cost $2.70 on the engine at that point, made up as follows:

	Coal J	Coal I
F. O. B. station	No. 4	No. 43
First cost	$2.50	$2.10
Haulage	.10	.50
Handling at chute	.10	.10
Cost on engine per ton	$2.70	$2.70
Cost on engine of amount equivalent to one ton of standard coal	2.25	2.25

"Coals E and F, Fig. 5, have also the same heat value and are from different sources of supply. The equation for finding the competitive point of these coals is as follows:

$$\frac{\$1.30 + \$\ .10 + x\ (\$.002)}{100\%} = \frac{\$1.10 + \$\ .10 + (600 - x)\ \$.002}{100\%}$$

$$x = 250 \text{ miles}$$

"This shows that at station No. 18 both coals cost the same, made up as follows:

	Coal E	Coal F
F. O. B. station	No. 13	No. 25
First cost	$1.30	$1.10
Haulage	.50	.70
Handling	.10	.10
Cost on engine	$1.90	$1.90

Unequal Heat Values, Equal Price, Same Source of Supply.—"Coals B and C costing the same, are supplied from the same source, but B is an 80 per cent. and C a 90 per cent. coal. As C is 12½ per cent. better than B, C should be used and B excluded.

Unequal Heat Values, Unequal Prices, Same Source of Supply.—"Coals A and D are supplied from the same source, but are different in both heat values and price, A being an 80 per cent.

* If the different coals will not mix without clinkering, or if the engine, as drafted for one of them, is not suitable for the other, the distribution should be modified to overcome it. H. T. Bentley, of the Chicago & North-western, called attention to a remarkable improvement in the performance of engines on that road due to an arrangement made by the purchasing agent whereby all the principal divisions are now served with either Illinois or Iowa coal entirely. Previous to this change some of the divisions had been served partly with one and partly with the other.

† On the Frisco System we are distributing coal on practically the basis outlined by Mr. Crawford, taking into account first cost, evaporative efficiency, labor of handling at 8 cents per ton and haul at three mills per ton mile. After making this distribution, which is revised from time to time (the efficiency of coals determined by actual locomotive test) we attempt in addition to take into consideration the difference in grade conditions as well as the direction of the prevailing light tonnage movement.—*Eugene McAuliffe.*

‡ There are many traffic conditions which will arise that will tend to make any predetermined coal distribution uneconomical for a short period on account of some haulage rate increasing; on the other hand there will be cases where the traffic conditions will tend to lower the established haulage rate. Thus, the advantage of the fuel department keeping in touch with the car and traffic situations, as mentioned by one of the speakers.—*J. G. Crawford.*

‡ The enormous cost of haulage of company coal is not as a rule fully appreciated. Company material amounts to about 10% of the total traffic of a railroad and the majority of this company material is coal. The importance of keeping the ton mileage of company material, and especially coal, to a minimum is thus seen. This can best be accomplished by knowing what the haulage of company material is costing and the most elaborate method of determining this would necessitate each shipment of company material to be billed at a rate representing the cost of haulage. In the case of coal the above results can be accomplished in a simple manner; thus: Each coaling station can arrange to keep record on a suitable form of a number of tons of each kind of coal used each month. This blank will then be forwarded to headquarters and the cost of haulage and handling inserted. This blank then gives a complete cost of the coal for each coaling station for each month and this cost is subdivided between first cost, haulage and handling. A summary of these blanks and comparison from month to month will soon show where improvement is to be made.—*J. G. Crawford.*

TABLE NO. 1.
A. B. C. RAILROAD COMPANY.
PRESENT COAL DISTRIBUTION AND COST OF COAL PER DAY.

	Tons Standard Coal	Coal Being Used.			Haulage.		Cost of Coal by Stations.			
Stations.	Required.	Kind.	Tons.	Per Ton Cost.	Miles.	Ton-Miles.	First Cost.	Hauling.	Handling.	Total.
1	200	A	250.0	$1.50	0	0	$375.00	$0.00	$25.00	$400.00
2	100	A	125.0	1.50	50	6,250	187.50	12.50	12.50	212.50
3	100	A	125.0	1.50	100	12,500	187.50	15.00	12.50	225.00
4	300	A	375.0	1.50	150	56,250	562.50	112.50	37.50	712.50
5	100	D	111.1	1.60	200	22,220	177.76	44.44	11.11	233.31
6	100	D	111.1	1.60	250	27,775	177 76	55.55	11.11	244.42
7	200	D	222.2	1.60	300	66,660	355.52	133.32	22.22	511.06
8	100	D	111.1	1.60	350	38,885	177.76	77.77	11.11	266.64
9	100	D	111.1	1.60	400	44,440	177.76	88.88	11.11	277.75
10	200	D	222.2	1.60	450	99,990	355.52	199.98	22.22	577.72
38	100	I	83.3	2.10	250	20,825	174.93	41.65	8.33	224.91
39	100	I	83.3	2.10	200	16,660	174.93	33.32	8.33	216.58
40	200	I	166.6	2.10	150	24,990	349.86	49.98	16.66	416.50
41	100	I	83.3	2.10	100	8,330	174.93	16.66	8.33	199.92
42	100	I	83.3	2.10	50	4,165	174.93	8.33	8.33	191.59
43	200	I	166.6	2.10	0	0	349.86	.00	16.66	366.52
11	100	E	100.0	1.30	100	10,000	130.00	20.00	10.00	160.00
12	100	E	100.0	1.30	50	5,000	130.60	10.00	10.00	150.00
13	300	E	300.0	1.30	0	0	390.00	.00	30.00	420.00
26	100	E	100.0	1.30	50	5,000	130.00	10.00	10.00	150.00
27	100	E	100.0	1.30	100	10,000	130.00	20.00	10.00	160.00
14	100	C	111.1	1.30	400	44,440	144.43	88.88	11.11	244.42
15	100	C	111.1	1.30	350	38,885	144.43	77.77	11.11	233.31
16	200	C	222.2	1.30	300	66,660	288.86	133.32	22.22	444.40
17	100	C	111.1	1.30	250	27,775	144.43	55.55	11.11	211.09
18	100	B	125.0	1.30	200	25,000	162.50	50.00	12.50	225.00
19	200	B	250.0	1.30	150	37,500	325.00	75.00	25.00	425.00
20	100	B	125.0	1.30	100	12,500	102.50	25.00	12.50	200.00
21	100	F	100.0	1.10	200	20,000	110.00	40.00	10.00	160.00
22	200	F	200.0	1.10	150	30,000	220.00	60.00	20.00	300.00
23	100	F	100.0	1.10	100	10,000	110.00	20.00	10.00	140.00
24	100	F	100.0	1.10	50	5,000	110.00	10.00	10.00	130.00
25	200	F	200.0	1.10	0	0	220.00	.00	20.00	240.00
28	200	G	181.8	1.40	450	81,810	254.52	163.62	18.18	436.32
29	100	G	90.9	1.40	400	36,360	127.26	72.72	9.09	209.07
30	100	G	90.9	1.40	350	31,815	127.26	63.63	9.09	199.98
31	200	G	181.8	1.40	300	54,540	254.52	109.08	18.18	381.78
32	100	G	90.9	1.40	250	22,725	127.26	45.45	9.09	181.80
33	100	H	90.9	1.20	200	18,180	109.08	36.36	9.09	154.53
34	200	H	181.8	1.20	150	27,270	218.16	54.54	18.18	290.88
35	100	H	90.9	1.20	100	9,090	109.08	18.18	9.09	136.35
36	100	H	90.9	1.20	50	4,545	109.08	9.09	9.09	127.26
37	200	H	181.8	1.20	0	0	218.16	.00	18.18	236.34
Total....	6,000		6,158.3			1,084,035	$8,840.55	$2.168.07	$615.83	$11,624.45
Average				$1.44	176		1.44	.35	.10	1.89

coal costing $1.50 per ton, and D a 90 per cent. coal costing $1.60 per ton. D being 12½ per cent. better than A and costing only 6⅔ per cent. more, should be used to the exclusion of A.

Unequal Heat Values, Unequal Prices and Different Sources of Supply.—"Coals D and J, Fig. 6, are unequal in heat value and price and are supplied from different points. Their competitive point would be found as follows:

$$\frac{\$2.50 + \$\ .10 + x\ (\$.002)}{120\%} = \frac{\$1.60 + \$\ .10 + (150 - x)\ \$.002}{90\%}$$

$$x = 14.3 \text{ miles}$$

"The competitive point of coals D and J is therefore fourteen miles north of station No. 4; chutes at stations No. 1, No. 2 and

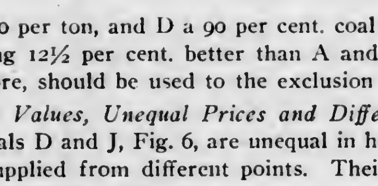


Fig.6

No. 3 should be supplied with D and station No. 4 with J. At the competitive point coal on the engine would cost as follows:

	Coal D	Coal J
F. O. B. stations	No. 1	No. 4
First cost	$1.60	$2.50
Haulage	.27	.03
Handling	.10	.10
Cost on engine per ton	$1.97	$2.63
Cost on engine of amount equivalent to one ton standard coal	2.19	2.19

"The competitive point of coals J and E, Fig. 7, is found from the following equation:

$$\frac{\$2.50 + \$\ .10 + x\ (\$.002)}{120\%} = \frac{\$1.30 + \$\ .10 + (450 - x)\ \$.002}{100\%}$$

$$x = 36.4 \text{ miles}$$

"This shows that J coal cannot be used east of station No. 4 and that E coal should be used at stations No. 5 to No. 13 inclusive. At the competitive point coal on the engine would cost as follows:

	Coal J	Coal E
F. O. B. station	No. 4	No. 13
First cost	$2.50	$1.30
Haulage	.07	.83
Handling	.10	.10
Cost on engine per ton	$2.67	$2.23
Cost on engine of amount equivalent to one ton standard coal	2.23	2.23

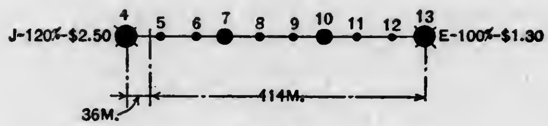


Fig 7

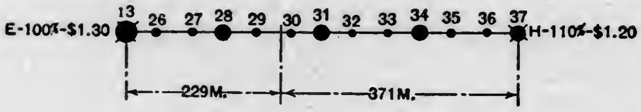


Fig.8

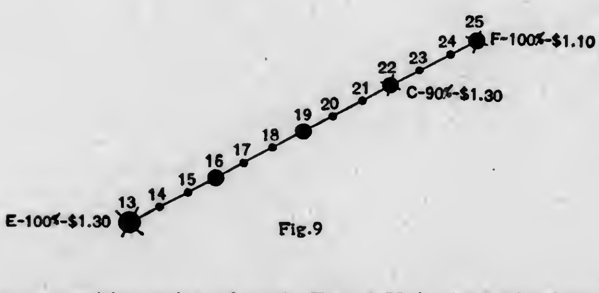


Fig.9

The competitive point of coals E and H is determined by the following equation, as shown in Fig. 8:

$$\frac{\$1.30 + \$\ .10 + (\$.002)}{100\%} = \frac{\$1.20 + \$\ .10 + (600 - x)\ \$.002}{110\%}$$

$$x = 229 \text{ miles}$$

"E coal is thus limited to station No. 29 and west thereof, and

TABLE NO. 2.

A. B. C. RAILROAD COMPANY.

PROPOSED COAL DISTRIBUTION AND COST OF COAL PER DAY.

	Tons Standard Coal	Coal to Be Used.			Haulage.		Cost of Coal by Stations.			
Stations.	Required.	Kind.	Tons.	Per Ton Cost.	Miles.	Ton-Miles.	First Cost.	Hauling.	Handling.	Total.
1	200	D	222.2	$1.60	0	0	$355.52	$0.00	$22.22	$377.74
2	100	D	111.1	1.60	50	5,555	177.76	11.11	11.11	199.98
3	100	D	111.1	1.60	100	11,110	177.76	22.22	11.11	211.09
4	300	J	250.0	2.50	0	0	625.00	.00	25.00	650.00
38	100	J	83.3	2.50	50	4,165	208.25	8.33	8.33	224.91
39	100	I	83.3	2.10	200	16,660	174.93	33.32	8.33	216.58
40	200	I	166.6	2.10	150	24,990	349.86	49.98	16.66	416.50
41	100	I	83.3	2.10	100	8.330	174.93	16.66	8.33	199.92
42	100	I	83.3	2.10	50	4,165	174.93	8.33	8.33	191.59
43	200	I	166.6	2.10	0	0	349.86	.00	16.66	366.52
5	100	E	100.0	1.30	400	40,000	130.00	80.00	10.00	220.00
6	100	E	100.0	1.30	350	35,000	130.00	70.00	10.00	210.00
7	200	E	200.0	1.30	300	60,000	260,00	120.00	20.00	400.00
8	100	E	100.0	1.30	250	25,000	130.00	50.00	10.00	190.00
9	100	E	100.0	1.30	200	20,000	130.00	40.00	10.00	180.00
10	200	E	200.0	1.30	150	30,000	260.00	60.00	20.00	340.00
11	100	E	100.0	1.30	100	10,000	130.00	20.00	10.00	160.00
12	100	E	100.0	1.30	50	5,000	130.00	10.00	10.00	150.00
13	300	E	300.0	1.30	0	0	390.00	.00	30.00	420.00
14	100	E	100.0	1.30	50	5,000	130.00	10.00	10.00	150.00
15	100	E	100.0	1.30	100	10,000	130.00	20.00	10.00	160.00
16	200	E	200.0	1.30	150	30,000	260.00	60.00	20.00	340.00
17	100	E	100.0	1.30	200	20,000	130.00	40.00	10.00	180.00
26	100	E	100.0	1.30	50	5,000	130.00	10.00	10.00	150.00
27	100	E	100.0	1.30	100	10,000	130.00	20.00	10.00	160.00
28	200	E	200.0	1.30	150	30,000	260.00	60.00	20.00	340.00
29	100	E	100.0	1.30	200	20,000	130.00	40.00	10.00	180.00
18	100	F	100.0	1.10	350	35,000	110.00	70.00	10.00	190.00
19	200	F	200.0	1.10	300	60,000	220.00	120.00	20.00	360.00
20	100	F	100.0	1.10	250	25,000	110.00	50.00	10.00	170.00
21	100	F	100.0	1.10	200	20,000	110.00	40.00	10.00	160.00
22	200	F	200.0	1.10	150	30,000	220.00	60.00	20.00	300.00
23	100	F	100.0	1.10	100	10,000	110.00	20.00	10.00	140.00
24	100	F	100.0	1.10	50	5,000	110.00	10.00	10.00	130.00
25	200	F	200.0	1.10	0	0	110.00	.00	20.00	130.00
30	100	H	90.9	1.20	350	31,815	109.08	63.63	9.09	181.80
31	200	H	181.8	1.20	300	54,540	218.16	109.08	18.18	345.42
32	100	H	90.9	1.20	250	22,725	109.08	45.45	9.09	163.62
33	100	H	90.9	1.20	200	18,180	109.08	36.36	9.09	154.53
34	200	H	181.8	1.20	150	27,270	218.16	54.54	18.18	290.88
35	100	H	90.9	1.20	100	9,090	109.08	18.18	9.09	136.35
36	100	H	90.9	1.20	50	4,545	109.08	9.09	9.09	127.26
37	200	H	181.8	1.20	0	0	218.16	.00	18.18	236.34
Total....	6,000		5,760.7			783,140	$8,058.68	$1,566.28	$576.07	$10,201.03
Average				$1.40	136		1.40	.27	.10	1.77

NOTE—At station 38 either J or I coal could be used with equal cost and J has been assumed as the coal to be used. Similarly with station No. 18 F coal has been assumed whereas E might be used.

H coal from stations No. 30 to No. 37 inclusive. At the competitive point the following would be the cost of coal on the engine:

	Coal E	Coal H
F. O. B. station	No. 13	No. 37
First cost	$1.30	$1.20
Haulage	.46	.74
Handling	.10	.10
Cost on engine per ton	$1.86	$2.04
Cost on engine of amount equivalent to one ton standard coal	1.86	1.86

"The competitive point of coals C and F, Fig. 9, is found from the following equation:

$$\frac{\$1.30 + \$\,.10 + x\,(\$.002)}{90\%} = \frac{\$1.10 + \$\,.10 + (150 - x)\,\$.002}{100\%}$$

$$x = -13.2 \text{ miles}$$

"Note that x is a negative quantity which shows that F can be hauled 26.4 miles more than the above 150 miles and then cost the same on the engine at station No. 22, the point of distribution of C, as the amount of C coal equivalent to one ton of standard coal. This is proven by the following table:

	Coal C	Coal F
F. O. B. station	No. 22	No. 25
First cost	$1.30	$1.10
Haulage	.00	.30
Handling	.10	.10
Cost on engine	$1.40	$1.50
Cost on engine of amount equivalent to one ton standard coal	1.55	1.50

Present vs. Proposed Coal Distribution, A. B. C. R. R.—"The present coal distribution on the A. B. C. Railroad is shown by Fig. 10 and the proposed distribution by Fig. 11. Some objection may be offered to the distribution shown in Fig 10, but when it is considered that the relative heat values are not known before tests have been made the distribution is not an improbable one.

"The cost of fuel per day under the present system of coal distribution is shown in Table 1, and that of the proposed distribution by Table 2. The following totals, Table 3, made up from Tables 1 and 2, show the amount of each kind of coal used under the present and proposed distributions:

TABLE 3.

	Present Distribution.		Proposed Distribution.	
Kind of Coal.	Tons Used.	Equivalent to Following Tons of Standard Coal.	Tons Used.	Equivalent to Following Tons of Standard Coal.
A	875.0	700	.0	0
B	500.0	400	.0	0
C	555.5	500	.0	0
D	888.8	800	444.4	400
E	796.0	700	2300.0	2300
F	700.0	700	1100.0	1100
G	636.3	700	.0	0
H	636.3	700	999.9	1100
I	666.4	800	583.1	700
J	.0	0	333.3	400
Total	6158.3	6000	5760.7	6000

"The following table shows the averages and totals of Tables 1 and 2, and shows the savings to be made by adopting the proposed distribution:

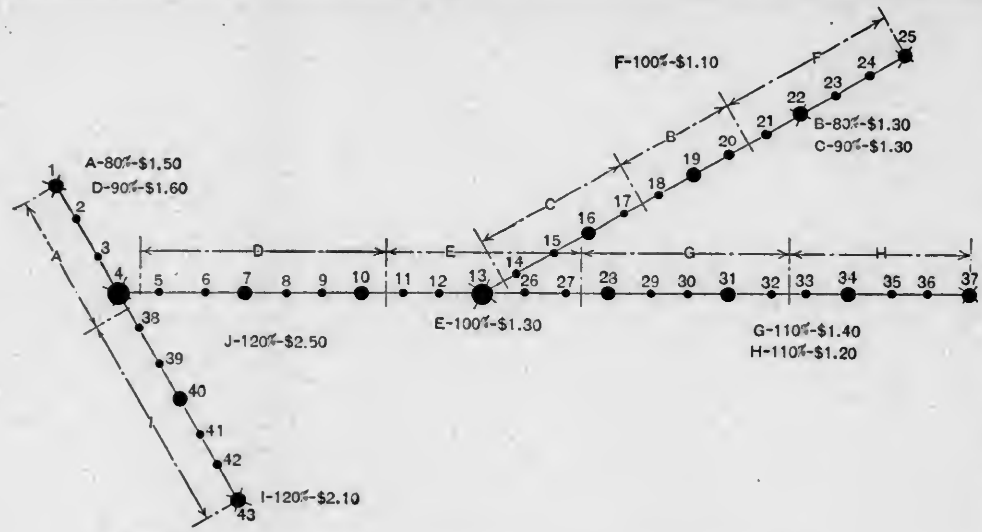
TABLE 4.

Coal		Average		Cost of Coal			
Distribution	Tons	Haulage	Ton Miles	First Cost	Haulage	Handling	Total
Present	6158.3	176	1,084,035	$8840.55	$2168.07	$615.83	$11,624.45
Proposed	5760.7	136	783,140	8058.68	1566.28	576.07	10,201.03
Difference	397.6	40	300,895	$781.87	$601.79	$39.76	$1,423.42

"The proposed coal distribution would effect a daily saving of $1,423.42 on a daily expenditure of $11,624.45, or a saving of 12.2 per cent.; $782 of the saving is due to the decreased amount paid mine companies; $602 due to saving in haulage and $40 is saved by having less tons of coal to handle, there being only 5,761 tons of coal used daily under the proposed distribution, as against 6,158 tons under the present distribution. The table also shows the decrease in the average length of haul and the decrease in total ton miles.

"It is not expected that every railroad company in working out a coal distribution would find that there could be a saving of over 12 per cent. made by distributing the coal according to the methods herein outlined, but there is no doubt but what considerable saving is to be effected on most systems.

"It is not expected that any railroad can at all times distribute coal according to some predetermined plan, but the cost of fuel will be considerably less, when purchased and distributed ac-



NOTE

- Denotes coaling station using the equivalent of 100 tons standard coal per day.
- Denotes coaling station and division point using the equivalent of 200 tons standard coal per day.
- Denotes coaling station and division point using the equivalent of 300 tons standard coal per day.
- X Denotes source of coal supply.

Distance between coaling stations, 50 miles.
Distance between division points, 150 miles.
Numbers indicate name of coaling stations.
Letters denote name of coal.
A-80%-$1.50, shows that coal "A" having a heat value of 80% of the standard coal is supplied at $1.50 per ton F. O. B. cars.

FIG. 10.—PRESENT COAL DISTRIBUTION ON A. B. C. R. R.

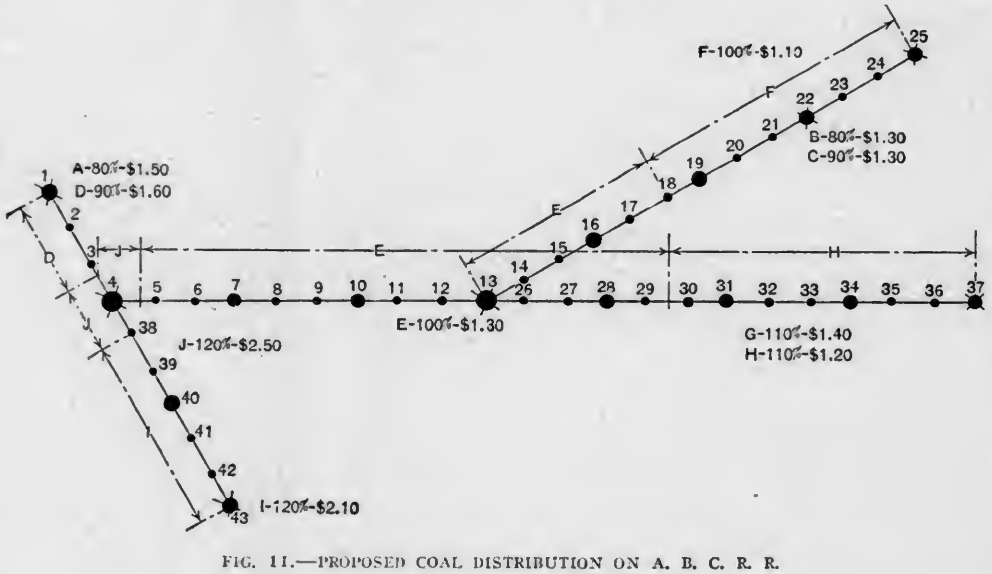


FIG. 11.—PROPOSED COAL DISTRIBUTION ON A. B. C. R. R.

cording to its heat value and cost, than though purchased and distributed in a semi-haphazard manner.

"The greatest saving can probably be effected when the commercial demand is not at a maximum, which will prove beneficial to purchase and distribution by allowing more economical coals to be used and correspondingly less amounts of the less economical coals."

Types of Locomotive Coaling Stations and Cost of Handling Coal.

The best discussion of the utility of the various types of locomotive coaling stations in use is to be found in the reports made by the "Committee on Buildings" of the American Railway Engineering and Maintenance of Way Association at the 1907 and 1908 conventions. The parts of these reports which refer to coaling stations are quite completely reproduced in this section.

The cost of handling the coal at the coaling stations, as ordinarily compiled by the railroads, includes only the cost of operation and sometimes of maintenance. Interest and depreciation and the cost of storage in cars are entirely neglected, and the comparison of the results gained on one road with those on another, or even between two divisions on the same road, is useless. They are worse than useless for comparing the economy of different types of plants. The committee has emphasized this point and submitted recommendations as to what should be included in these costs. The accompanying table of costs of different types of stations has been tabulated from information presented in the report of the 1907 committee. In lieu of exact information the committee has estimated certain items in order to make the costs roughly comparable, but the information cannot, of course, be considered as exact; the number of stations considered is comparatively small and the conditions under which they are operated are not given, so that this information should be used in a general way only.

The report of the 1907 committee is as follows:

"*A locomotive coaling plant should minimize: Delays to engines while coaling; delays to coal cars; the cost of handling coal; sometimes it is also desired to accurately measure the coal as delivered to locomotives.*

"An ample storage capacity insures against delays, due to interruption of coal supply, to bunching of engines and to breakdowns, derailments and necessary repairs. At important points, it is sometimes desirable to provide duplicate machinery.

The roundhouse track arrangement should be as compact as possible and at the same time allow the necessary free movement. The question of the proper location of the coaling plant with reference to the cinder pit depends upon the type of plant adopted. In cold weather, delay to the engine after the fire is cleaned is liable to cause leaking, though some of the trouble attributed to this cause is probably due to an unwise use of the injector. Some handle cinders with the machinery for handling coal. This practice is, however, not recommended.

"The importance of providing storage room so as to cut down the delay of cars as much as possible is ordinarily underestimated. One day's storage in cars of locomotive coal for the Pennsylvania System costs more than $300,000 a year, figuring that the cars are worth only one dollar a day each. An expenditure of $4,000,000 would be justified to avoid holding two days' supply of coal in cars, considering that the structure costs 15 per cent. of the original cost for interest, depreciation and maintenance.

"Figuring 40 tons to the car, storage in cars costs 2½ cents per ton per day, and an expense of $61 a ton is justifiable to avoid it. Ordinarily, storage in the bin is much cheaper than in cars, yet the usual practice is to keep from one to five days' supply stored in cars at the different plants.

"Theoretically, a coaling plant should be designed to take care of all the coal to be held for emergencies, so that cars can be released promptly upon arrival. This is, of course, not always feasible.

"All plants for self-clearing cars should have the hoppers wide enough so that the coal can be shoveled from flat bottom cars by hand, if desired, and so that side dump cars can be used.

TYPE—SEE SECTIONS IN ARTICLE	A	B		C	D	E				F			G	I			J					K		
TYPE OF COALING STATION.	COAL SHOVELED FROM CAR TO TENDER.			Coal shoveled into small dump cars	TRESTLE TYPE—CARS PLACED BY LOCOMOTIVE.					TRESTLE TYPE—POWER OPERATED			LOCOMOTIVE CRANE.	BALANCED TWO-BUCKET TYPE.			LINK BELT.					ROBBINS BELT TYPE.		
		Jib crane	Jib crane																					
No stations considered	1	1	1	4	5	6	2	17	1	1	5	55	3	6	1	1	1	1	3	4	1††	4	1	1
Av. No. tons handled per day (all stat'ns)				235	133	305	370	444			166		195	247					147	345		280		
" " " " " " each "	157	12	13	59	26	51	175	26	67	264	33	82	65	41	113	50	165		49	86	450		127	218
Interest and depreciation—per ton	$.002	.014	.017	.008	.010*	.005	.012*	.008*	.023	.017	.027	.027	.015	.019	.022	.038	.037*	.020	.025	.018	.116	.017	.032	.033
Operation—per ton	$.104	.123	.206	.103	.113	.031	.061	.036	.028	.035	.051	.070	.039	.045	.035	.087	.027	.049	.037	.024	.028	.027	.043	.031
Maintenance—per ton	$.001	.020*	.022	.005	.005*	.005	.006*	.004*	.001	.008*	.013*	.009	.005	.005	.005*	.005	.010*	.016	.010*	.005	.021	.005	.006	.005
Car Storage—per ton	$.066	.075	.075	.062	.047	.050*	.043	.050*	.050*	.056*	.000	.037	.075	.043*	.020	.025	.044	.058	.041	.047	.019	.044	.041	.000
Total cost—per ton	$.173	.232	.320	.178	.175	.091	.122	.098	.102	.116	.091	.143	.134	.112	.082	.155	.118	.143	.113	.094	.184	.093	.122	.069
Time covered by above figures (months)						10	1	1	9	3		1	24	10	3	1	6	60	1		3	10	12	3
% Self clearing cars	0	0	0	0	0	90		100	75		‡	67	0	63		66				80		90		

* Estimated. ‡ Large proportion self-clearing. †† Special construction and with scales.

"In this statement, the figures which are not available have been estimated. In order to make a fair comparison, we have assumed that it is desirable to hold at the plant, either in cars or on the ground, a total of three days' supply. The figures presented are of value in a general way only. We have used ten per cent. of the original cost for interest and depreciation for all plants, independent of the character of construction. Considering the present rate of development, the necessary changes in terminals, etc., this is believed to be none too high. A good many of the plants reported have not been in operation long enough and the length of time over which the costs extend is too short, in most cases, to make the maintenance figures reliable. The lack of uniformity in the collection of the statistics and the varying conditions under which they were prepared, make any close comparisons of little value. They indicate how much a slight variation in the conditions, not generally considered, can affect the cost. In considering this question, it should be remembered that a saving of dollars per year for the railroad, and not cents per ton for the individual plant, is the result to be aimed at."

COMPILED FROM DATA IN THE REPORT OF THE COMMITTEE ON BUILDINGS AT THE 1907 CONVENTION OF THE AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.

"Self-clearing cars can be unloaded into a hopper for at least six cents a ton less than the cost of unloading flat bottom cars by hand. Using 15 per cent. per annum of the original cost as the cost of the plant, an expense of $146 is justified to save handling one ton a day by hand.

DESCRIPTION OF PLANTS.

A.

"Where the quantity of coal handled is small and especially at terminal points where the engines lie over night and the coaling can be done by the hostler or watchman, coaling direct from the cars is the cheapest. This work can be aided by elevating the track, on which the coal cars stand, from two to four feet above the locomotive track.

Shoveling from the coal car direct into the locomotive has the advantage that it delivers the coal in the best possible condition. Crushing, due to handling, is kept at a minimum and large lumps can be broken up ready for the fire by the shoveler. The tendency of large bins to separate the slack from the lump is avoided.

B.

Coaling from Cars with a Jib Crane.—"Where the engines are needed as soon as they can be cared for, where they come bunched, or where the hostlers cannot do all the coaling in connection with their other work at the time desired, it is recommended that there be, in addition to the elevated track, an elevated platform with buckets of about one ton capacity into which coal can be shoveled at different times, these buckets to be raised by a jib crane which can be operated by hand or by air from the engine, and to be emptied when the engines come too fast for the men to take care of them. By this method the cost can be kept down to almost that of coaling direct from the cars into the engines. These buckets can be used for emergency coaling stations en route where coal is only occasionally required.

C.

"By having, instead of buckets, small dump cars on an elevated platform and the coal car track elevated considerably above the track on which the locomotive stands, more engines can be coaled quickly.

D.

Williams-White Type.—"By still further increasing the elevation, the shoveling can be done directly into bins, by which the amount stored can be increased and a larger number of engines accommodated promptly. These bins can be filled with different amounts of coal, so that, by selecting the bin, the amount needed can be obtained. With all of the designs, thus far considered, flat-bottom cars are practically necessary.

E.

Trestle Type.—"The next step is the construction of the high trestle with the coal car track on top of the storage bins, thirty or forty feet above the engine track. The cost of switching is increased, but by the use of self-clearing cars the cost of delivering coal from the cars to the bin can be almost entirely eliminated. The maximum grade of the approach desirable is usually considered as five per cent. Where the coal is not shoveled, this type of plant keeps the breakage of the coal at a minimum of all plants where the coal is not shoveled by hand. In considering the expense of operating these plants, the cost of placing the cars on the trestle by a locomotive, an expensive and dangerous operation, is not ordinarily included.

F.

Power-Operated Trestle Type.—"Instead of using a locomotive to place the cars, these plants can be equipped with a hoisting engine, allowing the use of a twenty per cent. grade. The machinery costs less than the trestle approach, much ground space can be saved and the operation is cheaper and safer when the cost of switching is considered. This type ordinarily increases the possibilities of providing storage room and does away with a considerable liability to accident.

"Where two or more tracks are to be served and the necessary room is available, the coal car track can be put at right angles to the locomotive tracks. In some cases, where it is desired to coal on four tracks or on two main tracks, duplicate plants are constructed.

"The trestle types are handicapped by the fact that the structure must sustain heavily loaded cars and also either locomotives or have power available to raise the cars. The costs per ton for maintenance are higher than is generally assumed, and if a fireproof structure is built, it would be expensive. They ordinarily

cannot be placed in the most desirable location, and are not available in many cases where the room is cramped.

G.

Locomotive Crane Type.—"At terminals, where the demands are not too great, coaling can be done by means of a locomotive crane handling the coal direct from flat-bottom cars to a locomotive. This crane can also help switch coal cars, if necessary, and can handle cinders and sand. To allow the use of drop bottom cars, a pit can be constructed from which the crane can handle the coal. To avoid delay to locomotives, a trestle can be constructed on which the crane can work, so that it can load direct into bins, in which a fair amount of storage room can be provided. The bins are not protected from the weather, and the coal and gates are liable to be frozen up.

"With the necessary tracks, the pit and the hoppers, it will be found that this sort of a plant has a considerable first cost. Its cost of operation depends upon the work which can be provided for the crane at spare times. Its value is great in emergency situations and at points where, because of impending changes, the construction of a permanent plant is unwise.

"At a large terminal, where a conveyor plant is used, a locomotive crane would be very valuable to handle cinders and sand and also coal during a possible breakdown of the conveyor. The practical limit of a locomotive crane is said to be about 70 engines a day. The fact that it can unload direct from flat-bottom cars is much in its favor.

H.

Clam-Shell Bucket and Trolley Type.—"A type of plant using a special bucket of the clam-shell type operated on a trolley has been suggested. This can handle coal direct from a pit or from flat-bottom cars into bins over the tracks, and can also handle cinders. While this device has not yet been tried for coaling locomotives, it is receiving more or less attention and will undoubtedly be tested soon. The number of tracks it can serve is unlimited, and the mechanism is simple. The horse-power required is small and the first cost is not excessive. This type would be especially valuable where self-clearing cars cannot be regularly obtained and where large storage is desired. It is believed that with a plant of this type, coal can be handled from flat-bottom cars at a reasonable cost. There should be no difficulty in getting an actual working capacity of seventy-five tons an hour, which is ordinarily ample.

I.

Balanced Two-Bucket Hoist.—"When the space is more or less limited and the amount of coal to be handled and stored is not too great and deep foundations can be constructed, the coal can be lifted into bins by means of two large buckets, operating opposite each other, so that when one is lowered, the other is raised. The coal is delivered into the buckets by gravity from the bottom of a pit under the coal car track through a gate worked by the operator of the bucket. The bucket is automatically dumped into the bins at the top. It requires the continuous attention of a man operating it, but is an efficient machine where the requirements are not too great. The storage room in the bins is limited by the fact that this plant has practically but one point of delivery into the bin.

J.

Link-Belt Type.—"The bucket conveyor or link-belt type requires a small ground space, has great flexibility of adjustment to suit different conditions, and can be used for almost any situation desired. With the softer grades of bituminous coal, such as that from the Indiana fields, these plants tend to break up the coal. Many of these plants are in operation, and, where well cared for, are giving excellent service. The expense of power and repairs are not great, and, where the conditions are such as to recommend their construction, they give good service at a reasonable cost.

K.

Robbins Belt Type.—"Plants raising the coal on a continuous belt of rubber and cotton on an incline of about thirty degrees are coming into use. The maintenance cost is reasonable, and in most situations it can be as readily fitted in as any other type. In some locations, where ample space is available, a better storage yard for coal cars can be provided with this than by any other type, as the receiving hopper can be placed at a considerable distance from the storage bins in any direction. There are very few parts of this which can get out of order. The ordinary objection to this type is the expense of belt renewal, but this is only about 0.2 of a cent per ton, a comparatively small amount, which makes no appreciable difference in the total cost of maintenance.

GENERAL INFORMATION.

"For large plants, where coal is delivered in self-clearing cars and an unloading hopper is used, tracks can be so arranged that cars can be handled by gravity, without the need of switch engines, decreasing the cost of operation.

"A locomotive crane as an auxiliary for handling cinders, sand and coal in emergencies, is very desirable.

"Although most roads do not now consider it necessary to weigh the coal accurately as delivered to locomotives, some plants are built with this provision. Storage bins, holding as much as one hundred tons, on scales, are used, or else auxiliary bins on scales, with a capacity of five or ten tons, are placed underneath the large storage bins. The use of scales is sometimes avoided with trestle plants by providing small auxiliary pockets in which the measuring can be done by volume. The scales add considerably to the cost.

"With belt or bucket conveyors, the bins should be designed so as to prevent an accumulation of slack. Slack coal in considerable masses, which is not moved for a long time, may cause spontaneous combustion. If it collects, it will finally slide out in large masses, so that one engine may be furnished with a very considerable amount of it, in which cases the performance of trains is seriously interfered with. This trouble can be prevented by designing the bins with hopper bottoms and by placing the points of delivery into the bins directly over the points from which the coal is taken. The slack is then used as it is delivered. If this is not done, the slack will drop directly from the points of delivery, and large lumps will roll to the mouth of the chutes.

"With some grades of coal, where run of mine or lump is used, it is necessary to provide means of breaking it up. Breaker bars can be either placed over the hopper, which will not allow any coal above a certain size to pass without being broken up, or else a crusher can be provided. The breaker bars deliver the coal in better condition, but are more expensive in operation.

"Where softer grades of coal are used, it is important that the plant be designed to avoid breakage as much as possible.

"The handling of sand and cinders is frequently attempted in connection with coaling stations, but, unless separate machinery is provided, they have not generally been successfully operated, due largely to the excessive wear caused by the cinders and sand on the moving parts.

"Some efficient method of fire protection is very desirable, many expensive plants having been destroyed by fire.

"The recent and prospective increases in the cost of labor and timber and the demand for greater reliability of service tend to increase the desirability of having better coaling plants built of steel or reinforced concrete."

CONCLUSIONS AS AMENDED AFTER DISCUSSION.

(1) *The cost items should include charges for interest and depreciation, charges for maintenance and operation (the cost of switching cars onto trestles should be included), and a charge for the use of cars for storage purposes.*

(2) *Provision should be made for fire protection, the avoidance of damage to the coal, and its delivery in the best possible condition.*

(3) *The use of self-clearing cars should be made possible, and ordinarily it should be possible to shovel from flat-bottomed cars.*

(4) *Storage for emergency purposes and fireproof construc-*

tion are, in general, to be recommended, and in some cases duplicate machinery is desirable.

RECOMMENDATION OF 1908 COMMITTEE.

An abstract of the report on the "Best Types of Locomotive Coaling Stations for Various Conditions," as presented by the Committee on Buildings at the recent meeting of the American Railway Engineering and Maintenance of Way Association, is as follows:

"Your committee desires, however, at this time to emphasize the need of adequate fire protection at all coaling stations and to call attention to the possibilities of reinforced concrete construction of coaling stations and storage bins, which has been used in some instances, as a method of reducing fire risk, and at the same time securing structures of greater permanency than those ordinarily in use.

"The average insurance rates for open trestle timber construction coaling stations and reinforced concrete fireproof structures are, respectively, one per cent. and one-fourth of one per cent. This would mean that from the standpoint of fire insurance alone we would be justified in expending fifteen per cent. more for a reinforced concrete structure than for a timber coaling station. As the relative cost of the fireproof style of structure at present is about fifty per cent. above that of the heavy timber station, an expenditure of the extra twenty-five per cent. may, perhaps, be justified on the ground that the smaller chance of incidental losses due to interruption of traffic will warrant this additional expense.

"To the 'general information' in last year's report should be added that the 'Balanced Two-Bucket Type' of coal elevator is now built with auxiliary horizontal conveyors, which receive the coal from the elevator buckets and distribute it to bins and pockets, thus adapting it to use in larger coaling stations and storage plants than are practicable for the simple balanced bucket type of coaling station.

"In presenting the following conclusions your committee has been guided by the apparent practicability and adaptability of the various devices rather than by the available statistics regarding comparative costs of handling coal, which are, as has been stated, somewhat unreliable, and consequently not worthy to be accepted as the sole basis for comparison."

The following conclusions are an addition to those adopted at the meeting of 1907:

CONCLUSIONS OF 1908 COMMITTEE AS AMENDED.

(5) *"It is not possible to give absolute limits between which different types of coaling arrangements are to be used. Each installation must be considered as an individual problem. Prices of materials, cost and character of labor, the possible track arrangements, the amount of storage desired, the power and attendance, and shifting service available, all are to be considered.*

(6) *"Where the quantity of coal handled is small, particularly at terminal points where locomotives lie over night, it is recommended that the locomotives be coaled, either directly from cars or by handling from cars to a platform provided with a jib crane and one-ton buckets, and from these buckets to the locomotive.*

(7) *"At terminals, under certain conditions, a locomotive crane, with suitable bucket, is desirable, particularly where other work can be economically performed by the crane."*

(8) *"At terminals where the requirements do not exceed 300 tons a day, when the desired storage is not so great that auxiliary buckets are necessary and where a deep foundation is practicable, a 2-bucket hoist is recommended."*

(9) *"For terminals larger than those previously considered, the type of coaling station which should be selected as most desirable is dependent entirely upon local conditions. Where it is required that coal be delivered to not more than two tracks and where the necessary ground space is available, a coaling station of the 'trestle type,' with incline approach, is recommended. In yards where delivering locomotives are constantly available a plant with a five per cent. incline is preferable to one with a twenty per cent. grade operated by a hoisting engine. Where it is required to deliver coal to more than two tracks, or where the ground space for a 'trestle type' is not available, a 'mechanical conveyor type' is recommended."*

Weighing Coal Issued to Locomotives.

There are several methods by which the coal delivered to the locomotive tenders may be measured with more or less accuracy. Unfortunately most roads have several types of coaling stations, built from time to time, some of which measure or weigh the coal issued, while others do not.

Unquestionably the greatest gains which may be made in fuel economy are in its use on the locomotive. The enginemen, however, cannot be watched closely and spurred on to better efforts unless a careful check is kept on the coal consumption and on those things which effect it. This cannot be done unless some means is provided for measuring the coal issued to each engine with a fair degree of accuracy.

Under proper supervision there seems to be little question but what the average fireman could save one scoopful of coal in every ten. Would this not many times over warrant the installation of weighing or measuring devices on your road, also the establishing of a system of simple daily fuel performance reports, such as is described in another section of this article?

The simplest method of measuring the coal is the use of the jib crane and bucket system, or where "buggies" are used. The average weight of coal which one of these buckets or buggies will hold can easily be determined and care can be taken to see that they are loaded uniformly each time. As a large percentage of existing coaling stations are of the above types the practice on the Nashville, Chattanooga & St. Louis Railway, under the direction of Geo. M. Carpenter, fuel inspector, may be of interest.

Two standard sizes of buggies, holding two and three tons of run of mine coal each, are in use. It is the duty of the foremen at each chute to see that these are filled to capacity and a report is made to the fuel inspector each day as to the initial and number of the car from which each buggy is loaded and the number of the engine to which it is delivered. The fuel inspector can therefore check the weight of each car as against the mine weights, can easily find what kind of coal was used on any engine, and in case of poor coal can at once take the matter up with the inspector at the mine from which the coal was shipped.

The tanks on all the engines are graduated for each ton, the graduation being stenciled on the leg of the tank. This was done by weighing into a buggy one ton of coal, dropping it into the tender, leveling it off to a uniform depth and making a mark on the leg. This was repeated for each ton until the tank was filled level full. When an engine arrives at the roundhouse, at the end of a run, a man shovels the coal down from the sides and back of the tank, levels it up and marks on a coal ticket the "pounds on arrival." To this is added the amount of coal taken. It is thus possible to determine with a close degree of accuracy the amount of coal used on each trip, and with very little extra expense.

Another of the older types of coaling stations which allows the coal to be measured is the low trestle type with different size pockets into which the coal is shoveled from the cars. This type of station does not permit the use of self-clearing cars, and is becoming obsolete, but where it is in use the coal can be measured quite accurately if the pockets are properly calibrated.

With the large overhead storage pockets the problem becomes a more difficult one. The scheme has been tried of suspending the entire pocket and introducing a weighing dynamometer but it is of course necessary to have the pocket hang plumb in order to get accurate results; a wind or an eccentric loading interferes with this.

An arrangement which is being used successfully by several roads is to have an auxiliary pocket underneath the storage pocket. A simple scale arrangement is used for weighing this auxiliary pocket. Accurate results are attained and it is said to be inexpensive to maintain.

In the December, 1904, issue of this journal, page 65, coaling stations on the Baltimore & Ohio Railroad were illustrated and described which have auxiliary or delivery pockets under the

large storage pockets. The delivery pockets are in pairs, each pair holding four and two tons. The coal is dumped into these self-measuring pockets by the tipple man who operates a gate controlling the flow from the storage pocket, from what is known as a measuring pocket platform. The coal can be dumped from the measuring pocket to the tender either from the platform or from the engine cab.

In connection with the discussion of a committee report on "The Most Approved Method of Unloading Locomotive Coal Prior to Being Unloaded on the Tender," at the 1901 meeting of the Master Mechanics' Assn., F. A. Delano, then with the C. B & Q., mentioned a coaling station which delivered coal on each side and which had four track scales, two at each end. The empty tender was first weighed at one end, coal was taken and the tender again weighed at the other end of the coal chute. The scales were twenty feet long and the arrangement had been in operation with satisfactory results for a year, at a point where 125 to 150 engines were handled daily. The matter came to our attention too late to follow it up. If it has been discontinued, due to the scales not being able to stand up under the severe service, it is quite probable that much better results could be obtained at present, due to improvements which have been made in track scales in recent years. If satisfactory scales are available it would seem to offer a comparatively cheap and satisfactory means of securing accurate results.

The coal pits on the tenders can also be calibrated, assisting the coal chute foreman to make a fairly close estimate of the amount of coal issued, but it is necessary to level the coal off before additional coal is dumped in, and this would be more or less objectionable when coaling on the road.

Wastes at Fuel Stations.

Lack of proper supervision and system at fuel stations will result in considerable waste or shortage. Mr. N. M. Rice, general storekeeper of the Santa Fé, recently made a careful study of conditions at the various fuel stations on that system, with a view of bringing about improvements in efficiency and economy.

Investigations.—The first step was to secure accurate information as to the conditions at each station. A personal visit was made to each one and data were obtained and noted on a sheet which was arranged to fit in a loose leaf note book. These sheets were about 5 x 8 in. in size, of fairly heavy paper and certain questions were printed on each side. The questions referring to the coal chutes were as follows:

At.............. Division..............
Date visited.
Class of chute.
Number of pockets.
Capacity of each pocket.
Total capacity, pockets.
Total capacity, bin.
Number of cars chute will hold.
Kind of coal used.
Coal supplied from.
Average No. tons issued, Day...... Night...... Month......
Average No. cars coal received, Day...... Month......
Chute droppings......tons, average per month.
Disposition made of chute droppings.
No. engines coaling. Day...... Night...... Month......
No. of men at chute, Day...... Night...... Extra......
Cost of chute labor.
Cost unloading per ton.
Cars hoisted by.
Make of engine.
How is check made on fuel issued?
Can correct weights be obtained without radical changes being made in chute?
What repairs are needed?
Possibility of loss of coal.
What check on this? (Question above.)
Chute foreman.
Remarks.

The form for the fuel oil stations contained the following questions:

At.............. Division..............
Date visited.
No. storage tanks and capacity.
No. tanks underground and capacity.
No. tanks elevated and capacity.
Total storage capacity of station
Oil supplied from.
Average No. gallons issued, Day...... Night...... Month......
Average No. cars received, Day...... Night...... Month......
Average No. engines taking oil, Day...... Night...... Month......
No. of men at station, Day...... Night......
Cost of labor for unloading.
Method of unloading oil.
How is check made of fuel issued?
Who measures oil issued to locomotives?
Who takes reading for monthly inventory?
Is water drained from tanks?
If so, is record kept of amount drawn off?
Possibility of loss of oil.
What check on this? (Question above.)
Are oil connections leaking or in need of repairs?
Foreman.
Remarks.

Wastes at Coaling Stations.—Mr. Rice's investigations indicated the following possible sources of loss at coaling stations:

Lack of supervision over coal chute foremen. These men, although they may be capable, are not always properly instructed as to the method of recording receipts and disbursements. Reports must be such that they may be checked by the auditing department. Measuring devices should be such that the fuel issued may be measured fairly accurately.

Incompetent chute foremen.

Delay in making necessary repairs at coaling stations.

Overloading engine tenders.

Improper or defective coal gates on tenders.

Wastes at Fuel Oil Stations.—Shortages at the fuel oil stations were found to be due to the following causes (largely due to lack of supervision):

Oil overflowing on the ground because of the unloading vats being too small, or due to carelessness in unloading.

Leaking pipe connections, both above and underground.

Leaks from submerged tanks.

Overflowing engine tenders and service tanks, due to carelessness.

Oil cars in leaking condition.

Engine tenders and engine connections leaking.

Improper opening and closing of valves on tank cars due to incompetent labor, often allowing a considerable amount of oil to escape.

Losses due to the overflowing of elevated supply or delivery tanks when filled by air pressure or steam, and caused by the carelessness of the pumper or the lack of proper regulating devices.

Organization of Fuel Department.

To remedy the above conditions a fuel department has been organized on the Santa Fé and placed under the direction of the general storekeeper. A fuel supervisor has been appointed on each grand division, who appoints and is responsible for the work of all employees engaged exclusively in the receiving, storing, delivering and of accounting for all fuel. He also receives and compiles all reports from the fuel stations and makes such reports as may be necessary to the audit or other departments.

Fuel inspectors (about one to each two divisions) report to the fuel supervisor. These inspectors see that capable men are placed in charge at the fuel stations, both day and night. They are expected to keep in close touch with conditions at the various stations and to take such steps as may be necessary to insure the economical handling of fuel and to prevent waste. They see that coal chute repairs are promptly and properly made, and that the coal chute pockets are properly marked to determine as closely as possible the actual amount of coal issued. They instruct the coal chute men with regard to overloading the tenders and also as to the method of making out the daily reports. They should attempt, in conjunction with the engineer, to reduce the issues of fuel as much as possible, by keeping in personal touch with the firemen. They are expected to ride the different engines, instruct the firemen as to the proper methods of firing and report any mechanical defects. To secure the best results they are furnished with a daily record of the operation of each coaling station and also of the fuel performance of each engine.

Each fuel station is in charge of a foreman. He must not only see that the fuel is properly unloaded and stored, but must measure all the fuel issued and make out the fuel tickets. He is also responsible for the proper loading of the tenders.

Reports in Connection with the Operation of Fuel Stations.

A system of telegraphic reports has been established on the Santa Fé by which the fuel foremen and agents advise the fuel supervisor each morning as to the amount of fuel at each fuel

Hell 1-8 2-M 8451

Form 1585 Standard.

Daily Coal Report.

7:00 A. M.________________190___ ________________DIVISION.

(A)	(B)	(C)	(D)				(F)	(G)	(H)		(J)				(K)	
STATIONS			DA	DB	DC	DF			HA	HB	JA	JB	JC	JD	KA	KB
			HOPPER CARS	TONS	OTHER CARS	TONS	TONS	TONS	CARS	TONS	HOPPER CARS	TONS	OTHER CARS	TONS	CARS	TONS
TOTALS																

(A)—Fuel stations.
(B)—Average daily requirements in tons.
(C)—Days' supply on hand in cars, chutes and bins.
(D)—Cars and tons on hand at each station, or moving in trains for this division's supply.
(F)—Tons in storage.
(G)—Tons in chutes or bins.
(H)—Amount of coal in cars, chutes or bins, using billed weights of cars for tonnage.
(J)—Cars Stock A coal held on division for movement to connecting division.
(K)—Received at each station.

FIG. 12.—SUMMARY REPORT FORM FOR TELEGRAPHIC COAL REPORTS—SANTA FE.

station and the number of cars en route, and where located. This gives the fuel supervisor complete control of the fuel from the time it leaves the oil fields or coal mines until it is issued to the locomotive. It enables the company to transfer fuel from one point to another with the least possible delay and prevents the holding of cars at points where they may not be needed immediately, thus assisting the transportation department in keeping more cars in service. The telegraphic reports are followed by detail reports by mail. Fig. 12 shows a summary sheet upon which the telegraphic coal reports are entered each day. The symbols are used to facilitate the handling of the messages.

When delivering coal or oil to an engine the fuel foreman makes out a ticket, Fig. 13, in triplicate; one copy is given to the engineer, another is sent to the fuel supervisor, and the third is retained in the book to protect the fuel foreman. The daily coal performance of each engine is watched closely, as will be described in another section of this article. The fuel consumption per ton mile depends upon the class of service in which the locomotive is engaged and to assist in the preparation of the reports for the different classes of service the coal tickets are of different colors; white for freight service, red for passenger, yellow for switch and blue for mixed freight.

Every twenty-four hours a report is sent to the fuel supervisor showing the issues made during that time and the conditions at each station. Fig. 14 shows the arrangement of this report for fuel oil. The report from the coaling stations is, of course, made on a different form.

The tender tanks are calibrated so that the amount of oil which is taken may be determined accurately. The coaling stations which have pockets are accurately calibrated and it is intended also to calibrate the coal pits on each engine tender.

Education of Firemen.

WHAT IS TO BE EXPECTED:—

When there is only one traveling engineer or fireman to from 400 *to* 1,500 *miles of road.*

When green firemen are placed on an engine without

(FORM 1131 STANDARD)

DAILY RECORD OF FUEL OIL ISSUED

*At*________________*Station*________________*190*___

Foreman's Number	Engine Number	ENGINEER	FIREMAN	Train Number	Service	After Taking	Before Taking	Quantity Taken	REMARKS
				TOTALS					

CARS UNLOADED INTO DELIVERY TANK

CAR		CAPACITY GALS.	DEPTH OF OIL		DO NOT WRITE IN THESE SPACES				REMARKS
INT.	NO.		FT.	IN.	ACTUAL GALLONS	DEDUCTIONS PER GAUGE TICKET	SHORT	OVER	

OIL INTO DELIVERY TANK FROM STORAGE TANKS

FILLING NO. 1
Gauge Reading After ______*Feet*______*In*______*Gals.*
" " *Before*______*Feet*______*In*______*Gals.*
*Amount Taken*______*Gals.*

FILLING NO. 2
Gauge Reading After ______*Feet*______*In*______*Gals.*
" " *Before*______*Feet*______*In*______*Gals.*
*Amount Taken*______*Gals.*

FILLING NO. 3
Gauge Reading After ______*Feet*______*In*______*Gals.*
" " *Before*______*Feet*______*In*______*Gals.*
*Amount Taken*______*Gals.*

FILLING NO. 4
Gauge Reading After ______*Feet*______*In*______*Gals.*
" " *Before*______*Feet*______*In*______*Gals.*
*Amount Taken*______*Gals.*
*GRAND TOTAL*______*Gals.*

This Record is for 24 Hours Ending at 6 p.m. Commencing at that time Tickets Must be Numbered from 1 up Consecutively each day

________________FUEL FOREMAN

FIG. 14.—DAILY REPORT FORM FOR FUEL OIL STATION—SANTA FE.

preliminary instruction as to their work, and are left to shift largely for themselves.

When the traveling engineer or fireman is an ex-engineer who was graduated from firing so long ago that his recollections of it are mellowed and softened by age.

When a traveling engineer or fireman has grown so portly that he cannot fire more than a few minutes before he is tuckered out—even if he has not a "biled" shirt on.

When most roads do not furnish the firemen with any printed instructions as to their duties and the proper method of firing, but often rely upon an inefficient force of traveling instructors who in some instances are entirely unsuited for this work.

When absolutely no record is kept of the coal performance of the different crews—in order that the poor firemen may be located and followed up; or if one is kept it is not issued until from 20 to 90 days after the end of the month and is ancient history before it comes to light.

When coal performance records entirely disregard the effect of poor dispatching and conditions not under the control of the engine crew.

When the amount of fuel issued is oftentimes guessed at by poorly paid and sometimes ignorant hostlers—not always proof against a good cigar.

When the duties of the traveling engineer or fireman often require him to spend the greater part of his time in connection with office work.

When the fireman himself is not ambitious and does not take a proper interest in his work—but what can be expected under some of the conditions mentioned above?

Traveling Engineers or Firemen.—Investigation shows that about two-thirds of the railroads have no special courses of instruction, or printed matter, to guide the enginemen in the economical use of fuel, but depend entirely upon the traveling engineers or firemen to instruct the men. This is all well enough if these men have been properly selected and are the right kind of men; if there are plenty of them, and if they are not loaded down with a lot of other duties which interfere with their riding on the engines and instructing the men. Unfortunately these ideal conditions do not pertain on many roads.

In discussing the qualifications of the road foreman of engines D. R. McBain, of the Michigan Central, spoke as follows before the last meeting of the Traveling Engineers' Association:

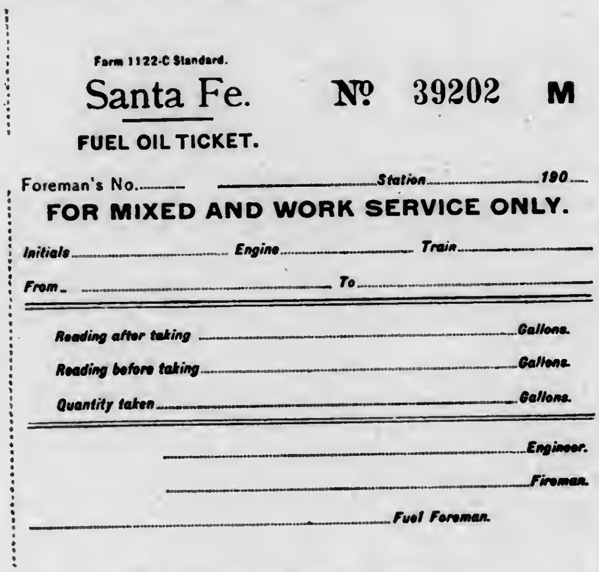
"Usually men are selected for these positions (road foremen of engines and traveling engineers) who are successful engineers, who are skilful men, and who are thought by their superiors able to impart such information as their success and skill would denote, to the rank and file of enginemen, where needed. The tremendously skilful man is not necessarily the most successful, as he is likely to give his men the idea once expressed in the hearing of the writer by a conductor who was about to start on his first trip in that capacity, that he drew the pay and what he said 'must go, right or wrong.' A better man for the position of road foreman of engines, or traveling engineer, is the man who will do his best to impart to his men such useful information as he is sure of and discuss with them any other point and not make a decision until he knows.

"Success and skill are not all that is essential in a road foreman, or traveling engineer. Good judgment, a cool head, a temperate tongue and a 'thick skin' are perhaps the best assets he can have, as without them he is not likely to possess the art of 'approaching' in a satisfactory manner, the rank and file of the enginemen with their various dispositions."

In addition to being a good instructor, and a good "mixer," the traveling engineer should preferably be a young engineer who has had a first-class record as a fireman and can get down and fire, when necessary. The remark has been made that if a test for traveling engineers was given, similar to that which President Roosevelt arranged for the army officers in connection with riding, equally good results might be brought about. How can we expect to secure first-class traveling engineers, with the above qualifications, if the railroads are not willing to pay them more than they could make on the first-class runs?

Literature.—About one-third of the railroads use other measures for instructing the enginemen in the economical use of fuel, in addition to the instruction given by the traveling engineers. This consists in some cases of printed instructions as to the economical use of fuel, which are issued to each engineman; in some instances bulletins are sent out from time to time; in still other cases fuel meetings are held.

Only a few roads issue instruction books. On two roads, the Chicago, Burlington & Quincy, and the Great Northern, these books are quite elaborate. They include a section on economical firing, which treats of the theory of combustion and the proper methods of firing under varying conditions; a chapter on economical boiler feeding and one on the economical use of steam. Other roads furnish booklets, which may be purchased upon the open market, such as "Information," by George M. Carpenter, fuel expert of the Nashville, Chattanooga & St. Louis Ry., or "Fuel Economy," by George H. Baker.



Form 1122-C Standard.

Santa Fe. № 39202 M

FUEL OIL TICKET.

Foreman's No. ______ ______ Station ______ 190__

FOR MIXED AND WORK SERVICE ONLY.

Initials ______ Engine ______ Train ______

From ______ To ______

Reading after taking ______ Gallons.

Reading before taking ______ Gallons.

Quantity taken ______ Gallons.

______ Engineer.

______ Fireman.

______ Fuel Foreman.

FIG. 13.—FUEL OIL TICKET.

Several roads issue bulletins on fuel economy from time to time. One of the most successful bulletins of this kind is known as "Circular Letter No. 550," issued a number of years ago by R. Quayle, superintendent of motive power of the Chicago & North Western Railway. At that time the question of proper firing was attracting a great deal of attention and different roads were issuing instructions of various kinds as to the proper use of fuel. Mr. Quayle prepared a letter in which he called attention to the necessity for the cooperation between the engineer and fireman and followed this with what is known as a chapter of "don'ts." The result was a marked increase in efficiency and economy. These "don'ts" are as follows:

DON'T think because you are only one engineer or fireman, that what you do does not amount to much. It is the little drops of water that make the mighty ocean, and the little grains of sand that make up this earth of ours; so each individual, in the aggregate, can do a great deal. If each engine crew saves one-quarter of a ton or five hundred pounds of coal, this on a thousand locomotives would result in a daily saving of two hundred and fifty tons, or in round figures $157,000 a year.

DON'T neglect being at roundhouse in ample time to examine the firing tools on the engine before leaving the roundhouse. See that your ashpan, grates and flue-sheets are in good condition to make the run.

DON'T fill the boiler full of water as soon as you get out of the house. Leave a space so the injector can be worked to prevent popping, while air pump exhaust is fanning the fire, pumping air to make the terminal air brake test. If you do this your fire will be in better condition to pull out with. The noises of open pop prevent trainmen from locating leaks.

DON'T forget to start the lubricator a few minutes before leaving a terminal. Set it to feed regularly. The proper lubrication of valves and cylinders saves coal.

DON'T forget when starting trains, to do so carefully, thus preventing damage to drawbars and draft rigging. By so doing you will save serious delays to your own as well as other trains. All delays mean extra fuel consumption to make up time lost.

DON'T neglect using the blow-off cock, as it keeps the boiler clean and

water in good condition, and insures better circuation in boiler. Result: Better steaming engine and a saving in coal.

DON'T allow the engine to slip. This is an unnecessary waste of coal, wears out tires and rails, causes great damage to pins, axles and running gear, and generally results in spoiling a fire.

DON'T pull out of a station with a train (after engine has stood for a while, and fire was allowed to get low) without first giving the fireman a chance to build up the fire. The time lost waiting to do this will save coal, and can better be made up before reaching the next station. Remember this when you get a time order.

DON'T leave the reverse lever down in corner longer than necessary when pulling out of stations. No rule can be made to govern how the throttle and reverse lever should be used. This must be acquired by practice and observing the performance of the engine. Bring the lever up gradually, as speed is acquired. The lever hooked well towards center of quadrant, with throttle well open, usually gives better results than using the throttle to govern the speed. Up to five years ago we considered it good practice with our smaller power to run with wide open throttle, and as short a point of cut-off as possible consistent with weight of train, but in our heavier and larger engines we find that it is better at many times to throttle the engine. Particular attention is called to all wide fire-box type locomotives. The engineer can permit the reverse lever in these engines to remain low in the quadrant when starting from a station, for a greater length of time than with the other types of locomotives, without pulling the fire or losing steam. When you are running on short time, it would be good judgment for the engineer to take advantage of this when pulling out from a station. In this engineers will use their best judgment.

DON'T put four or five or more shovelfuls of coal into the fire at once. One or two shovelfuls will give better results, and these two should not be thrown in the same spot. It is good practice to fire on one side of the box at one time, and the next time on the other side of the box, in order that the bright fire on one side may take up the gases from the fresh coal on the other side. This will reduce the smoke and give more steam.

Always fire as light as possible consistent with your work. Very heavy firing will make your flues and staybolts leak, and in time will crack your fire-box sheets. The reason for this is that when you have a very heavy fire, the air will not pass up through it readily, and the gases pass off, because there is not sufficient oxygen to unite with them to produce combustion, and as the gases must get air from somewhere, the air is then pulled through the fire-door, causing the chilling of flues and sheets as referred to above.

DON'T allow steam to escape at pops unnecessarily. Frequent blowing off at pops shows improper judgment, and implies that the engine crew is not practicing economy. Tests have demonstrated that ¼ lb. per second or 15 lbs. per minute is wasted. This amounts to about one ordinary scoopful, and in most cases may as well have been thrown on the ground as into the fire-box. There are only 133 scoopfuls in a ton of coal, so you can see that you would only have to have your pops open one hundred and thirty-three minutes in a whole day in order to throw a ton of coal away.

DON'T open the fire-box door to prevent steam blowing off at pops when engine is working: dropping dampers is a better practice. The supply of air is cut off, and combustion is partially suspended. When engine stops blowing off, open dampers again, before putting in coal. This method keeps fire in better condition and saves coal. You have no doubt noticed that on Class R Locomotives, when working hard on a hill, you have to shut your dampers in order to keep your fire from turning over. This is because the exhaust pulls too much air up through the grates, and causes your coal to be too active, and to prevent this activity of coal as well as increased combustion which follows, we consider it a good thing to drop your dampers, as per above.

DON'T insist on having the maximum steam pressure with pops opening occasionally when handling light trains, when less pressure will handle the train on time, thus avoiding the opening of pops.

DON'T forget, when engine is shut off for stations, to drop your dampers, opening the fire-box door slightly if necessary, and using the blower to carry off the black smoke.

DON'T blame the engine or coal, if engine is not steaming properly, before you have ascertained whether or not both of you are doing your duty. Talk it over; see if injector is not supplying more water than is being used, or that fireman is not firing too light or too heavy. Heavy firing is responsible for more poor steaming engines than the lighter method. You all know some engine crews have better success than others with the same engines and conditions. Think a little: there must be some cause for this.

DON'T wait until you get the signal to pull out before building up the fire. This should be done gradually until the proper thickness has been reached. A good fire to start with is essential to maintain the proper steam pressure, while engine is working hard getting train under way. Afterwards distribute the coal evenly on sides, ends and corners. Do this systematically, keeping in mind where you have placed the last shovelful, thus avoiding getting holes in fire,and prevent piling up coal all in one place. Endeavor to keep the steam pressure uniform, with as little black smoke as possible. Experience has taught that engines with draft appliances properly adjusted require very little coal in center of fire-box.

DON'T permit the water to get so high in boiler that it is carried over into the valves and cylinders. This usually occurs when pulling out of stations, and the water carries off the oil, which not only results in cut valves and cylinders, but the extra friction damages the entire valve motion, to the detriment of the power of engine and the coal record.

DON'T gauge the amount of water an engine will safely carry by water coming out of stack. Keep it low enough to insure dry steam being used, because moist steam has the same effect as water. Usually one-half glass or two gauges give best results. Be careful, however, that when ascending a grade, and you are about to pitch over the other side, that you have sufficient water to keep your crown-sheet thoroughly covered. If your custom has been to carry high water, try less and note results in better handling of tonnage, also saving in coal and oil.

DON'T neglect to take advantage of your excess steam before your engine is about to pop off, by making a heater of your injector, blowing steam back into the tank to warm the cold water, but avoid getting it so hot that the injector will not lift the water. By doing this you will keep your engine from blowing off at pops, when standing at stations after the boiler is filled up. You have all tried warming the water in the tank to help a poor steaming engine, with good results. What is good for a poor steaming engine will surely help a good steaming engine do better. Try it and you will find that it will not only save work for the fireman, but will make a better coal record for the engine crew, besides keeping the tank from sweating, which you are aware spoils paint.

DON'T think the fireman alone to blame for your coal record. The best and most economical fireman cannot make a showing with an engineer who supplies more water to boiler than is being used, and who shuts injector off only when boiler is pumped full. The proper handling of the injector is one of the most important matters in saving coal. Feed water to boiler according to demands. If on through train, keep water level as possible. If on way freight or switch trains, lose a little water between stations. Fill up again while drifting into, standing or switching at station. The advantages of supplying less water than is being used between stations are: It requires less coal to keep up steam pressure when running; also leaves a space so injector can be worked to avoid pops opening, and heavier fire can also be maintained to do switching, without the possibility of the fire being pulled.

DON'T pull out, after making a stop, with injectors working. The cool water introduced during period throttle was shut off is put in circulation throughout the boiler, and pointer on gauge drops back from five to twenty-five pounds. The fireman must then fire heavier to regain the lost steam, and naturally will use more coal. This condition exists also when engine has gone down grade with throttle shut or slightly open. Shut the injector off before opening the throttle. If this is not your practice, try it and note the difference.

DON'T wait for the pops to open, and use this as a signal to put on the injector. Keep an eye on the air gauge, steam gauge and water glass. You all know this can be done without detracting your attention from the track ahead. A look for an instant every mile or two will keep you informed, and is a good habit. Doing this will also keep you posted on air pressure, and may avoid difficulties should the air pump stop. The fireman should also keep an eye on the water glass, as the engineer is sometimes compelled to keep the injector at work to prevent the engine blowing off. When glass is full, the fireman should fire lighter, to give the engineer a chance to shut off the injector, and not have engine blow off. However, this condition should only exist when injector cannot be worked fine enough to just supply amount used. This sometimes occurs when card time is slow, or on down grade, or when running with light train.

DON'T put too much coal under the arch of engines with sloping fire-boxes, because these engines naturally pull the coal ahead, which results in forward section of grates becoming stuck and clinkered over, and fire is pulled in back end of fire box. Experience and observation will teach you to put most of the coal in back end of fire-box.

DON'T think engine having two fire-box doors requires twice the quantity of coal it would if it had but one. The extra door is for the purpose of distributing the coal more evenly over the grate surface, with less effort on the part of the fireman.

DON'T shovel large chunks of coal into fire-box, because you find them on the tank. The coal house men have instructions to break it the size of an apple. If not properly broken, report it to road foreman of engines or to master mechanic, instead of fellow engineers or firemen, but don't think it a hardship to break some occasionally. Better break it than to throw in large chunks. They are foundations for clinkers.

DON'T expect the fireman to fire the engine with one or two scoops to each fire, and also ring the bell for highway crossings and stations. Some engineers expect this. If engine is equipped with an air bell-ringer, get into the habit of starting the bell-ringer when blowing the whistle. By so doing, the habit will become as fixed as whistling for crossings and stations. Besides, it is just as important. Remember the engineer is responsible.

DON'T put in a heavy fire about the time the engine is shut off for a station or down-grade. The heavy cloud of black smoke is evidence the engine crew is not working in harmony or practicing economy. If on train that stops at all stations, the fireman should guard against it and learn when to stop firing. He will be governed by grade, service and weather conditions. If train does not make all station stops, the engineer should keep the fireman informed of intended stops.

DON'T forget that different qualities of coal and different makes of grate used, govern the shaking of grates. Coal that fills up and clinkers, requires more attention than the better grade. The object is to keep the grates free so the proper amount of air can be admitted.

DON'T neglect cleaning your fire on trains that are long hours on the road. Make use of the first opportunity. You will get better results with less labor and coal, and avoid leaky flues. Better clean out a small amount two or three times than not clean it at all.

DON'T take coal or water oftener than necessary, as it requires an extra amount of coal to again get a heavy train in motion, especially on a grade.

Good judgment is required, in order not to run short before getting to next coal chute or water tank. Where possible take water only from tank containing good water, and as little as you can from tanks containing poor water.

DON'T forget that leaks in the air pressure are being kept up by an equal amount of steam pressure. As it takes coal to make steam, air leakage means a waste of coal. Keep apparatus on your engine tight, and insist on trainmen doing their part.

DON'T try to put more coal on tank than will lay on it securely. All coal dropped off by overloading is wasted. Also keep coal from falling out of gangway when running. This may be only a little each day, but it all counts against your coal records, besides it looks badly when strewn along the tracks. You can not save coal by the ton; it must be in pounds, which in time make tons.

DON'T forget to make an intelligent report on your work slip on arrival at roundhouse. Consult your fireman in regard to any defect that has come to his notice, especially with grates, dampers or firing tools.

DON'T neglect reporting the pop valves ground in when leaking or when they blow back eight or ten pounds before seating. Also report leaky piston rod and valve stem packings, or if cylinder packing or valves are blowing. All these leaks draw on the coal pile unnecessarily; it takes coal to generate the wasted steam. This also applies to leaky steam heat appliances, cylinder cocks, etc.

DON'T neglect looking at coal report each month to see how you stand in relation to others in same service with whom you are comparable. The other crews get the same pay you do, and it should be your aim to be as economical with both fuel and supplies as they are, other things being equal. Keep posted and be with the average. It will be to your credit and interest some time; therefore aim to be at the top.

DON'T think when coal report shows you using only two pounds more per 100 ton miles than other crews in same service, it is close enough. This means two pounds more used for every mile you hauled 100 tons—or another way, two pounds for every 100 tons hauled one mile. Figure this up and you will find in hauling 1,000 tons 100 miles, a difference of 2,000 pounds or one ton. This method of showing up the individual record is more equitable to all than on basis of miles run per ton of coal.

DON'T think, after reading over this chapter of "DON'TS" you should save coal to the detriment of the service. The actual amount required to make up time, keep on time, or handle tonnage, is not what we are trying to save; it is the waste. You will notice the proper method of handling the engine to the extent of the economical use of fuel only has been considered.

Fuel Meetings.—On several roads fuel meetings are held from time to time. On the Chicago, Milwaukee & St. Paul these coal meetings are held at the various division points three or four times a year. In addition to the engineers, firemen and mechanical officials, the local operating officials are also present. The men are encouraged to express their views and criticize methods and these meetings have been instrumental in bringing about splendid results, not only as concerns the work of the engine crew but also in connection with the operation of the trains, etc On another road in the middle west the assistant superintendents of motive power recently went over the divisions where they were best acquainted and hired halls and talked to the enginemen on the economical use of coal.

Coal Premiums for Enginemen.

The practice of paying premiums to enginemen for the economical use of fuel is being used extensively abroad. It has been tried to some extent in this country—has in fact been used for a number of years on several large systems. Two important roads have recently discontinued the practice in this country and as far as we have been able to ascertain it is not now in extensive use on any road.

Some of the more important reasons urged against its use are as follows: The systems ordinarily used for determining and checking the amount of coal placed on the tender are far from perfect; the grade of coal used on many roads varies considerably, sometimes even on the same division; the engine crews are not credited with excess consumption of fuel due to poor dispatching and adverse conditions not under their control; the condition of power is far from uniform. Possibly the most important reason is that fuel is comparatively cheap and as yet there is not the same stern necessity for fuel economy as there is abroad. Undoubtedly the time is not far distant when the railroads may be forced to practice far greater economy than is now used and conditions will gradually come about which will make it possible to secure the same careful, systematic service from enginemen as is found in England and on the continent.

Among several questions on the use of fuel on locomotives, which were recently submitted to a number of superintendents of motive power was this: Do you pay your enginemen premiums for the economical use of fuel? The answer was in all cases in the negative. Extracts from three of the letters, which touch upon this question, are as follows:

"We maintained a coal premium system for many years. It was discontinued at a comparatively recent date, with the idea that by the addition of instructors, and an increase of inspectors, the economical use of fuel would be promoted better than with what had gotten to be a very complex system of coal premiums."

"The premiums given to enginemen for saving in fuel have lately been abolished, as it has not proven economical. This system was based on the ton mile."

"For a number of years we kept an individual record of the coal consumption by each engineer, and gave them a credit mark each month based upon the number of pounds of coal per loaded car mile; but, after a thorough trial for a number of years, we reached the conclusion that there were so many variables entering into the computations that they were really not accurate, and, in some cases, misleading. I think the engineers themselves became impressed with this idea, and lost interest in endeavoring to secure high rank on fuel performance. The men who made the best records in many cases are the same men who have since maintained good fuel records, and would do so under any conditions, they being the men whose interest and pride is in doing their life work well; the other class are hard to reach or to stimulate; we, therefore, after carefully considering the matter, felt that the expense of keeping individual records was not justified, and that form of record has been dropped; for the same reasons, we do not pay fuel premiums to engineers or firemen."

Some railroad officers believe that a premium system established under proper conditions offers one of the most inviting means of effecting economies, not only in the use of fuel but in other directions. The indications are that the matter will be tried out on at least one road and under conditions which will be radically different from anything which has been done heretofore in this country.

The premium system on one of the French roads was described on page 91 of the March, 1905, issue of this journal in connection with one of G. M. Basford's letters on "Impressions of Foreign Railroad Practice." This road pays premiums not only for fuel economy but for making up time when the enginemen are not responsible for the delay, for economy in lubrication, and for runs independent of premiums for economy. They are fined for excessive fuel consumption and irregular runs. These fines are rigidly enforced unless the engineer can prove that it was due to some cause over which he had no control.

Fuel Premiums for Traveling Engineers.

One road pays its traveling engineers premiums based on the average fuel consumption for each division. Allowances are made for each class of service, as follows:

Heavy passenger trains, one ton per 10,000 ton miles.
All stock or time freight trains, .8 ton per 10,000 ton miles.
All other freight trains. .9 ton per 10,000 ton miles.
Switch, work trains or helper engines, .25 ton per 10,000 ton miles.
Idle under steam, .025 tons per hour.

The superintendent of each division keeps an accurate record for each engineer and fireman, showing the coal consumed for each trip, the coal allowed and the excess.

The traveling engineers have a fixed salary of $125.00 per month. In addition they receive $1.00 for each point the percentage is reduced below the allowance for the first 10 points and $5.00 per point thereafter. Changes are made in the schedule to allow for winter and summer weather. Very satisfactory results are claimed for this method.

Fuel Performance Records.

Daily versus Monthly Reports.—The monthly engine performance reports, as compiled on most roads, are not issued until from 15 to 60 days after the end of the month and are of little value in checking up the fuel performance of the different crews. While they show the relative performance of the different crews in a general way, they do not distinguish clearly enough—in most cases—between the different kinds of service in the same general class, nor do they take into consideration conditions which may materially affect the fuel consumption, but which are not under the control of the enginemen. Because of this, these reports seem to have gradually lost their value as a means of spurring the men on to better efforts.

Realizing this, at least four roads have established what is known as "daily engine performance reports" which show the

tonnage, fuel consumption, weather conditions and train movement of each run. These reports are issued the day following, or at the latest the second day after the trip. In general, excessive fuel consumption is due to adverse weather conditions, poor train movement, poor fuel, a defective locomotive or poor work on part of the engine crew. If the weather conditions and train movement are favorable the responsibility for poor performance lies between the fuel, condition of locomotive and the crew. The matter is at once taken up with the roundhouse foreman and the engine crew, and the trouble is located. These reports have resulted not only in the more economical use of fuel, but have called forcible attention to the poor condition of locomotives and fuel. In some instances they have been the means of bringing about better train movements.

The four railroads using the daily report system are the Chicago, Milwaukee & St. Paul Railway, the La Crosse division of the Chicago, Burlington & Quincy, the Great Northern Railway and the Atchison, Topeka & Santa Fe Railway. The methods of collecting and compiling the data for the "daily reports" on these roads, and in fact the reports themselves, differ considerably, although they are intended to accomplish the same general result. This may be seen from the following descriptions:

Daily Engine Performance Reports.

Chicago, Burlington & Quincy.—In 1905 Mr. N. Frey, master mechanic of the La Crosse division of the Chicago, Burlington & Quincy Railroad, put into effect a system of daily engine coal and delay reports, which not only effected a considerable saving in fuel but has otherwise improved the service.

The following results gained during 1905 and 1906, as compared with 1904, are of interest:

COAL PERFORMANCE.

Through Freight Service.

	1904.	1905.	1906.
Total ton miles	1,133,402,447	1,265,182,755	1,401,072,722
Tons coal used	85,823	86,712	89,192
Lbs. coal per 100 ton miles...	15.1	13.7	12.7

Improvement in Pounds of Coal Used per 100 Ton Miles.

1905 over 1904......................	1.4 lbs.
1906 " 1904......................	2.4 "
1906 " 1905......................	1.0 "

To handle 1905 tonnage on basis of 1904 would require 8,856 more tons of coal valued at $15,055.00. To handle 1906 tonnage on basis of 1904 would require 16,862 more tons at a cost of $28,665.00. To handle 1906 on basis of 1905 would require 7,005 more tons at a cost of $11,910.00.

This system was not applied to passenger service until 1906. The following is a comparison of the results gained during that year and 1905:

COAL PERFORMANCE.

Passenger Service.

	1905.	1906.
Total car miles	3,048,016	4,152,334
Total tons coal used..................	25,047	28,855
Lbs. of coal used per car mile.........	16.4	13.9

Saving 1906 on Basis of 1905.

In lbs. per car mile..................	2.5
In tons of coal......................	5,190
Value of coal saved..................	$8,853.00

One of the daily coal performance sheets is shown in Fig. 15. The division superintendent furnishes the items "engine," "train," "miles," "tons" and "engineer" from the dispatcher's train sheet. The coal clerk in the master mechanic's office adds the tons of coal used and the fireman's name, and calculates the ton miles and the pounds of coal used per 100 ton miles.

The engineers are required to fill out a delay report for each trip, Fig. 16. The cause of the delay is entered in the column headed "remarks." When the coal clerk has completed the coal performance sheet he attaches the delay reports to it and hands it to the master mechanic. If the coal consumption per 100 ton miles is excessive for a certain run the master mechanic or the road foreman of engines can refer to the delay report and see the exact conditions under which the run was made. If the delays on the run are not excessive and the weather conditions are favorable something must be wrong with the grade of fuel, the firing, or the engine, and the matter is at once taken up with the engine crew and the roundhouse foreman.

At some points on the division the coal is actually weighed when it is delivered to the engine; at others it is measured in buckets, while in some cases the hostler estimates it. The tenders start from the terminal with a full load. Wherever coal is taken the hostler fills in a slip in the engineer's coal book and tears it out and forwards it to the master mechanic's office by mail. Before the small slip is torn off (there are three of them attached to each large slip) the proper notation is made on the large slip shown in the illustration (Fig. 17) and on the stub, which is similar to it. At the end of the run coal is taken; the

ENGINEER'S DAILY COAL PERFORMANCE.

Date Aug. 3rd 1907

Engine	Train	Miles	Tons	Ton Miles	Tons Coal	Pounds Per 100 T. M.	Engineer	Fireman
2032	X	157	2,260	354,820	22	12.4	Allison	Nicolay
1906	80	"	1,850	290,450	16	11.0	King	Layland
2103	X	"	2,550	400,350	20	9.9	McEldeny	Haidon
2042	X	"	1,660	260,620	20	15.3	Galloway	Irwin
2078	81	"	2,020	326,560	16	9.8	Boyer	Smith
2031	77	"	2,710	425,470	23	10.8	Adam[illegible]	[illegible]

FIG. 15.—DAILY COAL PERFORMANCE REPORT, LA CROSSE DIVISION OF CHICAGO, BURLINGTON & QUINCY RAILROAD.

amount burned on the trip is therefore equal to that taken on the run and at the end of the trip. The hostler at the terminal forwards the large coal slip to the master mechanic's office. The daily coal performance reports are being used in connection with the way freight service, as well as with the through freight and passenger service. The results with the way freight are, however, not as accurate, as the tonnage used in the calculations is that of the train when it reaches the terminal. It has been found that this usually agrees quite closely with the actual average tonnage during the run. If necessary, the actual tonnage could be secured but the conditions on this division are such that it is not thought necessary.

The cost of keeping these records is about $25.00 per month. In addition to checking up the poor enginemen it has been found of great value in locating mechanical defects. The engines in the through freight service are pooled and if a certain engine shows up poorly with two or three different engine crews the roundhouse foreman is asked to give it a thorough inspection, and invariably something is found to be wrong, such as leaky steam chest bushings, steam pipes, etc. When the report was first started seventeen loose piston valve bushings were located and renewed. Under ordinary conditions these would probably not have been discovered for a considerable time.

The delay reports are quite necessary in connection with the coal reports, as they place the responsibility between the operating and mechanical department and the engineman is not called

Train 81 From Sav. Yd to G Xing Date 8-3-07.

Stations	Meeting Passing	Set Out Pick up	Coal or Water	Orders Block	Hot Box Eng. Cars	Misc. Delays	Remarks
G Xing							
LaCrosse							
South Jct.		10					Set Out
Stoddard						20	Surfacing Gang
Rusk	10						Ex. 273
Genoa	10						Track Gang
Victory		5	10				Pick up - Water
De Soto							
Perryville	15						Meet 52
Lynxville							
Charme							
Pra. du Chn.		10	10				Set Out - Water
Crawford							
Wyalusing							
Bagley							
Glen Haven						5	Unload
Dewey							
Cassville	22		6				Meet Ex. 2032 - coal
McCartney							
Potosi						5	Unload
Blake							
Rutledge							
E. Dubuque		10	10				Set Out - Water
E. Cabin							
Portage				5			Block
Galena Jct.							
Hanover							
Marcus							
Savanna						10	Unload
Total	57	35	36	5		40	

Departed 5^{16} a.m. Arrived 4^{10} P.m. Hours 11

Average speed, delays excluded 19.4 No. cars 61

Engine 2028 Engineer Boyer

Weather Cond. Clear Fireman Smith

FIG. 16.—ENGINEER'S DELAY REPORT, C. B. & Q. R. R.

to account when the fault is in the dispatching. Monthly performance sheets are also prepared and posted in the roundhouses. The accompanying table shows part of one of these monthly reports. The crews are divided into what is known as first and second class; those in the first class have a coal record better than the average and those in the second class below it. The record reproduced is for through freight service. Separate reports are issued for way freight service and passenger service.

PERFORMANCE OF ENGINEERS IN FREIGHT SERVICE ON LA CROSSE DIVISION.

Month of December, 1907.

Engineer.	Fireman.	Total Ton Miles.	Tons Coal.	Pounds per 100 Ton Miles.	Cost for Hauling 1,000 Tons 1,000 Miles.
First Class.					
Lakowsky, F. E.	Fisher	3,290,605	162	10.0	85.00
Snyder, C. J.	Smith	5,908,873	299	10.0	85.00
Larson, C. L.	Bell	2,482,766	146	11.8	100.30
Johnson, W. S.	Pruetz	2,957,526	183	12.4	105.40
Boyer, John	Dixon	5,564,709	353	12.7	107.95
Total and average:—					
This Mo.		122,554,778	8472	13.8	117.30
Same Mo. last year		131,192,432	9305	14.2	120.70
Last Mo.		154,952,831	10553	13.6	115.60

Chicago, Milwaukee & St. Paul Railway.—The Chicago, Milwaukee & St. Paul Railway has had in effect for a considerable time what is known as the "Train Dispatcher's Daily Report of Train Tonnage and Coal Consumption." The form for this report is shown in Fig. 18. The conductor wires in the gross tonnage of the train from certain points known as "tonnage points," places where a change is usually made in the tonnage.

The coal pits of the tenders are supposed to be filled when the train leaves the terminal. The foremen at the coaling stations wire in, once a day or more, the amount of coal given to each engine. The dispatcher determines the total amount of coal used on the trip by adding the amounts for each engine, including that when the tender is filled at the end of the trip. With this information in hand it is the matter of only a few minutes to calculate the other information on the form. To facilitate the making of these calculations a set of tables, in book form, has been arranged by Mr. W. M. Harvey, auditor of material accounts. These are arranged so that it is possible to quickly find the ton miles, knowing the tonnage and mileage. Having found this and having the pounds of coal used on the trip, other tables are included to determine the pounds of coal consumed to haul 100 tons one mile.

These daily reports are completed the day following, or at the most the second day after the run. One copy of the report is sent to the auditor of material accounts and the other is kept by the dispatcher. If the fuel consumption is excessive for a certain trip and the train has not been badly delayed and the weather conditions have been favorable, the matter is called to the attention of the mechanical department, and the condition of the engine is looked into and the enginemen are called upon for an explanation.

Based upon these train dispatcher's reports a statement is prepared each month by the auditor of material accounts, showing the train miles, ton miles and average tons per train for the east and west bound trains on the different divisions; also the train miles, ton miles, average tons per train, pounds of coal consumed, average pounds of coal per 100 ton miles and average miles per hour for all of the trains on each division. This is for main line service only and makes it possible to compare the average performance on the different divisions. Under the "average tons per train" and "average pounds of coal per 100 ton miles" are three columns, so as to show the comparative figures for the same period during the previous year and the gain or loss over that year.

Atchison, Topeka & Santa Fe Ry.—In connection with the organization of the fuel department on the Santa Fe (see page 134), it has been found advisable to institute a system of daily engine performance reports to assist in locating the poor firemen and following them up, to locate mechanical defects or defects in design which may effect the coal economy, and to check the improper dispatching of trains.

The daily coal performance sheet may best be understood by reference to Fig. 19. As may be seen the greater part of this form is prepared from the train dispatcher's report. The information in the column marked "not to be filled in by train dispatcher" is filled in by the fuel supervisor. The coal or fuel oil consumed is taken from the daily reports sent in by mail from

H-11-07-750 Form 4361. 3

Chicago, Burlington & Quincy R. R. Co.

Engine No. ____

____ Engineer

____ Fireman

Date ____ 190__ Train No. ____

From ____ To ____

Date ____ 190__ Train No. ____

From ____ To ____

Coal in Tank at start, ____ Lbs.

Coal Taken at ____ ____ Tons

Coal Taken at ____ ____ Tons

Coal in Tank at end of trip, ____ Lbs.

Total Coal consumed, ____ Lbs.

Coal Taken at ____ ____ Tons
(For next trip)

3

Burlington Route **C., B. & Q. R. R. Co.**

Engine No. ____

____ Station

____ 190__

Coal ____ Tons

Wood ____ 16th Cords

Charge ____

____
Engineer.

FIG. 17.—COAL TICKET, C. B. & Q. R. R.

Form 661

CHICAGO, MILWAUKEE & ST PAUL RAILWAY.

TRAIN DISPATCHER'S DAILY REPORT OF TRAIN TONNAGE AND COAL CONSUMPTION

Division. Date. 19

TRAIN NO	TRAIN MILES	CONDUCTOR	ENGINE NO.	ENGINEER	FIREMAN	TONNAGE LEAVING	TON-MILES	AVERAGE TONNAGE PER TRAIN	COAL CONSUMED	POUNDS OF COAL PER 100 TON MILES	TIME IN SERVICE HRS.	TIME IN SERVICE MIN.	REMARKS
EAST BOUND.													
TOTAL AND AVERAGE.													
WEST BOUND.													
TOTAL AND AVERAGE.													
GRAND TOTAL AND AVERAGE.													

Percentage of rating hauled ....

Dispatcher.

FIG. 18.—TRAIN DISPATCHER'S DAILY REPORT OF TRAIN TONNAGE AND COAL CONSUMPTION, C. M. & ST. P. RY.

Form 614 Standard

Santa Fe.

.......DIVISION (Insert name of Railway)

DAILY TRAIN TALLY SHEET, AND TRAIN DISPATCHER'S REPORT OF TRAIN TONNAGE AND FUEL CONSUMPTION PER 100 TONS MILES IN __________ SERVICE. DATE __________ 19__

Train No.	Kind Train	CONDUCTOR	ENGINEER (Initials and Name in full)	FIREMAN (Leave blank)	Engine No.	From	To	Actual Train Miles	Time Called	Time Left	Time Arrived	Total Time in Service Hrs.	Total Time in Service Min.	No. of Stops	TONNAGE LEAVING	Ton Miles (Not to be filled in by Train Dispatcher)	Coal or Oil Consumed (Not to be filled in by Train Dispatcher)	Average Tons per Train (Not to be filled in by Train Dispatcher)	Average Pounds of Coal or Oil per 100 Ton Miles (Not to be filled in by Train Dispatcher)	REMARKS If Light Engine show reason for running, etc.

NOTE:
- Be very careful to enter but one engine on a line.
- Be very careful to show run of each engine outside of yard limits, including double-headers, helping and light engines, and engines doubling hills (both up and down).
- In "Kind of Train" column state if train was freight, passenger, mixed, special, work, construction, light engine, engine helping passenger train or engine helping freight train.
- When work train runs some distance and then works between two points, be careful to show movement running and movement working, separately, giving time starting and stopping in each item.

This sheet to be made up in duplicate in Train Dispatcher's office daily, and forwarded without delay as follows:

For The A. T. & S. F. Ry., to: Ticket Auditor, Topeka. Car Accountant, Topeka. Three copies to Fuel Supervisor, Topeka.

For G. C. & S. F. Ry., to: General Supt., Galveston. Auditor, Galveston. Three copies to Fuel Supervisor, Cleburne.

For A. T. & S. F. Ry., Coast Lines, to: Car Accountant, Los Angeles. Auditor, Los Angeles. Three copies to Fuel Supervisor, San Bernardino.

For E. Ry. of N. M. System and S. K. Ry. Co. of Tex., to Auditor, Amarillo.

Weather conditions..........

Conductors are instructed to date their Train reports the day on which the train leaves, and the object of this sheet being to correct Conductor's reports, it is important that all Trains leaving Division stations before 12 o'clock, midnight, should be included.

In giving time when trains leave and arrive, be careful to say whether it is "A. M." or "P. M.," as in tracing cars of time freight it is necessary to know the exact time of arrival and departure of trains.

Construction and work trains are to be included in this sheet, showing between what stations they are at work.

All light engines must be shown, and in column of "Remarks" reason for movement entered, as "To even power," "Pusher returning to proper position," etc.

Reason for any unusual delays to trains must also be shown.

Make separate report for passenger and freight service.

....

Chief Train Dispatcher.

FIG. 19.—DAILY REPORT OF TRAIN TONNAGE AND FUEL CONSUMPTION, SANTA FE.

the fuel stations; the other items are calculated in the office of the fuel supervisor. These reports are ready within two or three days after each trip. The information on this sheet enables the fuel supervisor to determine at once whether excessive fuel consumption is due to poor dispatching, weather conditions, or to poor firing and a defective engine. If due to the latter causes, the matter is at once taken up with the engine crew, while it is still fresh in their minds. The results have been very satisfactory.

Two simple monthly performance reports are also used to advantage. One of them, Fig. 20, is for the operating officers and is a check on the train movement and fuel consumption. The second, Fig. 21, shows the fuel performance for the different engineers or engines and is posted in the engine houses each month. The last two columns show the total money gain, or loss, based upon the average cost per ton mile and serves to bring the importance of fuel economy forcibly before the men.

Great Northern Railway.—A daily bulletin of the performance of enginemen (Fig. 22) is posted at the division terminal roundhouses and copies are furnished to the road foreman of engines, master mechanics and superintendent of motive power. This statement covers road enginemen only; enginemen in service at

Hall 11 07 3M 7916 Form 1132 Standard.

Santa Fe.

DISTRICT. ....DIVISION.

Engineer .... 190...

Date	TRAIN No.	FIREMAN	ENGINE No.	STATION		TRAIN MILES		TOTAL TIME		No. of Stops	TON MILES		COAL OR OIL CONSUMED	REMARKS
				From	To	East	West	Hrs.	Min.		East	West		

FIG. 20.—MONTHLY FUEL PERFORMANCE REPORT FOR USE OF OPERATING OFFICIALS; SANTA FE.

other than division terminals are not considered owing to the difficulty of getting information promptly. These statements are posted in the roundhouse early each day and excessive consumption of coal and oil, and delays due to engine failures are promptly investigated by the road foreman of engines. If the amount of coal used is excessive in comparison to the time on the road, size of train, etc., the roundhouse foreman is instructed to make a careful examination of the engine and if it is found to be in good condition the matter is taken up with the engine crew. In this way cases of improper handling of the engine and poor firing are often located. Excessive time on the road and bad delays are referred to the superintendent and trainmaster.

These bulletins are said to be responsible for the prompt correction of such defects as leaky steam pipes, improper draft, worn packing rings, etc., as the engineers are careful to report all necessary work, and if the coal consumption is high special efforts are made to locate the cause. As may be seen by referring to the form, the train dispatcher, roundhouse foreman and engineer are each expected to fill in independently certain of the columns, in some instances offering a check upon each other and insuring accurate information. The figures for column 12 are taken from the coal ticket stub, which is filled in by the engineer and is turned in by the hostler after the tender is filled at the end of the trip. Columns 12, 13, 14 and 16 are furnished by the oil house man at the terminal and the engineer makes a report of any oil or waste taken at other points on the trip. The coal ticket is practically the same as that used on the Chicago, Burlington & Quincy, as illustrated on Fig. 17. The hostlers judge as to the amount of coal taken.

No monthly statement is issued as to the performance of the enginemen, but a statement is made up each month showing the performances of the different classes of locomotives on each division. This shows the mileage made by each class of engines, including light, freight, passenger, mixed, helper (freight and passenger), work and switch service and the total mileage for all classes; the gross tons one mile for freight service; the passenger train cars one mile; tons per draft; fuel consumed in tons for freight service, passenger service and both; the average price of coal per ton and its total cost; the cost of repairs, divided into ordinary, general, wreck and total; the pounds of coal per 100 ton miles of freight service and per 100 passenger car miles; the miles run per ton of coal in passenger and freight service and per pint of valve oil and engine oil; the cost per mile run in cents, divided as follows: fuel, repairs, wages, oil and waste, stores and total. These figures offer a direct comparison of different classes of engines engaged in the same class of service, making it possible to determine which class or type is the most economical for that service.

The Waste of Energy in Railroad Operation.

By D. C. Buell.

(This paper was read at the 1907 convention of the Traveling Engineers' Association. It is essentially a study of fuel economies, for while some of the matters mentioned may seem foreign to that subject, yet each one is reflected to a greater or less extent on the fuel bill. It serves to emphasize the fact that not only is it necessary for those in the mechanical department, who have actual charge of the fuel, to exercise care and judgment and co-operate with one another, but the various departments—purchasing, operating, maintenance of way and mechanical—must co-operate to secure the best results. The paper is worthy of the most careful thought and study.)

The energy wasted on railroads may for our purpose be divided into three classes:

First—Energy wasted by present well-established systems which, while known to be wasteful, nevertheless appear to be in

Hall 11 07 2M 7917 Form 1133 Standard.

Santa Fe.

(Insert name of Railway Company.)

FUEL PERFORMANCE OF ENGINES OR ENGINEERS.

............DIVISION MONTH OF............19....

NAME OF ENGINEER OR ENGINE NUMBER	TOTAL ENGINE MILES	TOTAL TON MILES	POUNDS OF COAL OR OIL CONSUMED	AVERAGE POUNDS OF COAL OR OIL PER 100 TON MILES	AVERAGE TONS HAULED PER TRAIN	TOTAL MONEY LOSS OR GAIN DUE TO PERFORMANCE SHOWN BASED UPON AVERAGE COST PER TON MILE	
						LOSS	GAIN
Division Totals							
Same Month Last Year							

Superintendent. Div. Master Mechanic. Fuel Supervisor.

Date............

FIG. 21.—MONTHLY FUEL PERFORMANCE REPORT OF ENGINES OR ENGINEERS, SANTA FE.

some cases the only practical, or, in others, the most economical means to accomplish the desired results.

Second—Energy now wasted by improper systems of management or improper or uneconomical machines or devices of various kinds now in use, these being under the control of officials higher than the road foreman of engines.

Third—Energy now wasted either by improper systems of management or by improper methods of handling or working machines, or the improper condition of the machines themselves, over all of which the jurisdiction of the road foreman of engines extends.

* * * * * * *

Science has proven that the mechanical equivalent of one heat unit (B. T. U.) is 778 foot pounds of work, so that to produce one horsepower for an hour would require power equivalent to 2,545 heat units. One pound of coal when properly burned will give off about 14,100 heat units, or enough to produce five and one-half horsepower for one hour. In locomotive service it takes at the lowest estimate twenty-five pounds of water (steam) per indicated horsepower per hour. Neglecting the loss due to friction of the engine, this would mean that to produce five and one-half horsepower per hour in a locomotive would require 137½ pounds of water, and as one pound of coal evaporates only about five pounds of water in a locomotive boiler, twenty-seven and one-half pounds of coal would be required, that is, only 3.6* per cent. of the actual energy in the coal is realized in this case, the other 96.4 per cent. being energy wasted, due to the method of converting the heat into work.

* * * * * * *

Aside from the method of generating power its use must be considered. The grade line of the road may be such that a very large amount of power is wasted. Possibly a small expenditure on grade reduction would more than pay for itself in power saved. The method of handling tonnage is also to be considered, as when the rating is too light energy is wasted by not using the machinery to its economical capacity, and vice versa; if an engine is overloaded, energy is wasted in slipping, stalling, in doubling hills and due to the much slower rate of speed at which train is moved, which is a controlling factor in considering the amount of energy wasted. The type of steam engine used is a factor also, some roads using very large and powerful engines, others using small power, some with compound locomotives, Walschaert valve gear, superheaters and other devices. all endeavoring to give greater economy and better service.

Each type of engine, valve gear or special device, if it has merit, shows its greatest economy under certain special conditions, and in order to save, rather than waste, careful consideration should be given to the selection of not only the locomotive, but the special devices on it, to insure having a machine that will be economical under the conditions under which it will have to work. The track conditions in a great many cases are such that the friction or train resistance of the cars passing over it is greatly increased over what it would be were the track properly maintained. All increased resistance of this kind, of course, means a corresponding waste of power.

* The Pennsylvania Railroad locomotive tests at St. Louis showed heat efficiencies of from 3 to 8 per cent. for the various locomotives under different conditions.

The foregoing cases are what might be called fundamental wastes on a road, that is, they are determined by the physical condition of the road, the class of power and equipment and the fixed policy of the management. There are numerous other wastes, however, that the road foreman of engines is directly interested in and which he can reduce to a minimum. There is a possibility of a large loss of energy due to improper lubrication of locomotives and cars. The subject has been so thoroughly worked up by the different oil companies that there is no question but what the amount of oil generally allowed for an engine or car is sufficient if properly used or applied. A waste of energy will occur, however, if the matter is not properly attended to. Dry valves on a locomotive will make a difference of twenty-five to fifty tons in the train load that can be hauled over the grades, and there is reason to believe that the waste would be greater in proportion on a comparatively level road. Hot pins, eccentrics, driving boxes, etc., cause waste through increased friction of the parts, although the loss of time caused is a much greater and more costly item than the loss through increased friction; the same is true of hot boxes on trains due to improper lubrication.

FUEL DEPARTMENT ORGANIZATION.

The problem of fuel consumption, or better combustion of fuel, is another serious matter. On most roads there is no one man who is held accountable for the amount of fuel used. It would seem that there is room on a railroad to-day for a man whose title might be fuel superintendent, who would have charge of and direct the work now done by the fuel agent, including inspection of coal and the assignment of certain grades of coal to various coaling stations. He would be so closely in touch with the mechanical department that he would be able to advise what class of coal was to be furnished each division point, so that engines might be drafted for the class of fuel to be burned, and he would have on his staff a corps of traveling firemen to see that the men were properly instructed concerning the principles of combustion and were firing their engines according to correct principles, and that the engines were drafted so that they would burn the fuel in an economical manner when properly fired. Such a man should be able to effect a wonderfully large saving when it is considered that to-day the fuel agent in some cases is trying to make a record by buying cheap fuel and will not admit there is such a thing as poor coal. The mechanical department, to avoid steam failures, is drafting engines to handle the poorest fuel, and the men on account of poor coal, improperly drafted engines, or lack of interest, are burning from ten to twenty per cent. more fuel than necessary.

Of other channels through which energy is wasted may be mentioned the following:

COAL WASTED.

Coal not properly inspected at the mines, allowing slack and dirt in considerable amounts to take up space in cars, tanks and fire-boxes that the coal should occupy, to say nothing of the loss caused by dirty fires, clinkers, etc.

Form 1449 11-07 15

GREAT NORTHERN RAILWAY LINE.

DAILY BULLETIN OF
PERFORMANCE OF ENGINEERS AND FIREMEN.

INSTRUCTIONS:—MASTER MECHANIC—This form to be filled in complete by Master Mechanic and posted in round house each day.
TRAIN DISPATCHER—Must fill in columns 1, 2, 4, 5, 6, 7, 8, 9, 10 and 11 for each train each day, 24 hours, and forward on first train to Master Mechanic.
ROUND HOUSE FOREMAN—Must fill in columns 1, 2, 3, 6, 12, 13, 14, 15, and 16 for each train each day, 24 hours, and forward on first train to Master Mechanic.
ENGINEER—Must fill in columns 1, 2, 3, 6, 12, 13, 14 and 15 for each run and hand to Round House Foreman at end of run.

Round House__________

						TRAIN			TIME		Consumption Supplies				
1 Date	2 ENGINEER	3 FIREMAN	4 FROM	5 TO	6 ENGINE	7 Number	8 Number of Cars	9 Tons	10 On Road	11 Delay	12 Tons Coal	13 Pts. Valve Oil	14 Pts. Eng. Oil	15 Lbs. Waste	16 Oil Used for Packing of Engines

FIG. 22.—DAILY BULLETIN OF PERFORMANCE OF ENGINEMEN, GT. NORTHERN RAILWAY.

Coal spilled at coal chutes and not picked up.

Coal stolen all along the line.

Coal wasted on account of improper or wasteful methods of firing up engines at the roundhouse.

Coal spilled from engine tanks being filled too full.

Coal spilled from engine deck on account of its not being kept clean.

Coal wasted through grates on account of the fireman shaking them improperly.

Coal wasted on account of firing not being properly done.

HEAT WASTED ON ACCOUNT OF:

Ash-pans not properly made for admission of air to give proper combustion or not kept cleaned out.

Engines not drafted right to give proper combustion.

Boilers or flues being dirty.

Steam leaks in fire-box or front end that interfere with the proper combustion of the fuel as well as wasting heat by the leakage.

Forcing the fire too hard, drawing the gases out of the stack at too high a temperature.

Engines not properly lagged.

Heat wasted which might be saved by hollow fire-brick arches, combustion tubes, feed-water heaters or special devices of this nature that have been proven economical.

STEAM WASTED DUE TO:

Valves or cylinder packing blowing.

Cylinders not smooth. That is, where the inside of the cylinder wall has not become glazed so as to reflect the heat and keep it in the cylinder, instead of absorbing it, and radiating it out as a cylinder which is pitted or unglazed will do.

Leaks across steam passages.

Leaks in steam valves.

Pipes or fittings leaking, either on the engine or in the cab.

Improper location of piping or working of the injectors.

Air leaks on the engine or cars.

Steam heat leaks.

Hot water leaks at any point from boiler or fittings.

Steam wasted through the pops on account of the engine not being fired properly.

POWER WASTED ON ACCOUNT OF:

Valves set improperly.

Lack of lubrication.

Improper feeding and firing of the boiler.

Improper running and handling of the engine.

Drafting the engine so as to give excessive back pressure.

Improper handling of the air.

Brakes set up too close.

The waste of time on a railroad is almost always accompanied by a waste of energy because cars, engines and men are lying around when they might be doing useful work.

TIME WASTED AT ROUNDHOUSE DUE TO:

Engineers not making proper work reports. Some one has said that the word "examine," as used by engineers on work book reports, has cost the railroad companies hundreds of thousands of dollars. Get your men to make correct work reports.

Inefficient or insufficient force not getting work done promptly, thus delaying a $15,000 machine for want of machinist or helper.

Sand-house, coal-chute, water tank and cinder pits not properly arranged. If you study your terminal you may be able to suggest some improvement in the layout that can be made at reasonable cost and would save more than enough in the cost of handling engines to pay the expense.

Lack of proper supplies at storehouse, requiring engineers to hunt up foremen and then spend more time robbing other engines to get what they want.

Lack of tools on engines, so that engineers cannot do necessary work promptly. A good locker room where tools, oil cans and overalls can be locked up will save most of this trouble.

Employing a boy who cannot be depended upon to do calling, when a few dollars more a week would pay for a man who would have some judgment and discretion and would save five times that amount in terminal overtime.

Not having a proper record of where men live and can be called.

Not having extra men enough to keep power moving as fast as ready and wanted.

Not having men called in time so they can get ready to go out on their call.

TIME WASTED ON ROAD DUE TO:

Not having proper tools on engines in case anything happens.

Trying to stop an engine at water tank with a long train instead of stopping short and cutting the engine off.

Not having fire in condition to go, after meeting a train or getting orders.

Not oiling around promptly.

Engineer and conductor not working together to make meeting points or figure on station work.

Careless handling of train and pulling out draw-bars and bad order of cars.

Not watching for signals from train crew.

Not having a supply of sand at convenient points between terminals for bad weather or emergencies.

Engines not properly washed out, causing foaming and consequent loss of tonnage or time.

Allowing coal to get in tanks, stopping up injector supply pipes.

Not cleaning strainers in injector supply pipes at frequent intervals.

Water accumulating in main reservoir, thus requiring a longer time than necessary to release brakes.

Not keeping sanding devices in good working order, with result that engine slips badly in starting train or on hard pulls.

Engineer and fireman not working together so they will have steam and water where needed.

Fireman not awaking to the fact that ash-pan needs cleaning until engineer and train crew are ready to go.

Engineer laying down when something goes wrong with his engine when with a little thought and some energy he could have fixed things and brought his train in.

Crew stopping to eat just where it suits them without notifying the dispatcher or regarding the possible disarrangement of his plans.

Engineer or conductor not advising dispatcher if anything is going wrong so they cannot make the time expected of them. This hurts the other fellow at meeting points and maybe ties up the road.

Engineer not willing to admit there is anything wrong with his engine, resulting in long arguments between engineer, conductor and dispatcher, with consequent waste of time. This is due in many cases to the fact that the engineer is "burned up" so badly if he admits an engine failure that he will deliberately say there is nothing wrong with his engine when he knows he could not make ten miles an hour with the train. Do not let your men get false ideas about not admitting there is anything wrong, so the train can be reduced if necessary.

There is a great deal of energy wasted in the yard and on the road directly chargeable to the transportation department, part of the cost of which in many cases falls on the mechanical department. For example, time wasted in not having trains made up, crews ready or the yard open so the engine can get to the train and get out on call.

Indifference in matter of switching coal to chutes, cars of company material to the rip track or roundhouse, switching bad orders to the rip track and pulling and setting rip tracks properly, pulling cinder track, etc. Along this line may be mentioned the seeming delight some switchmen take in blocking the roundhouse leads, so engines cannot get in or out.

There is also time wasted getting bills and orders, all of which is reflected in cost of coal charged against engines and wages of enginemen, etc.

On the road there may be waste due to poor distribution of time on schedules, poor dispatching, slow orders out which should have been canceled, orders put out at points where it is hard to stop and start when some place where train would have

to stop for water or a meeting point could have beer used just as well.

Another waste is due to trains being made up improperly, loads behind instead of ahead, empty car doors open, short loads in what is supposed to be a through train, etc.

Slow orders put out by the maintenance department also add to the fuel bill, because unfortunately they are usually necessarily placed on track just at the foot of a grade or on a curve on some hard pull.

Many water tanks are located so that it is up-hill both ways away from them. Of course, the streams are usually found at the bottom of hills, but it is cheaper to pump water to a tank at the top of the hill than to pull the train from a standstill to the same point; stations are located so the train has to be stopped on a curve, and sidetracks so that with a full train the brakeman has to jump off and sprint for the switch, because "if they stopped they would have to double in."

LOCOMOTIVE FIRING.

The possibilities of fuel saving are probably greater after the coal has been placed upon the locomotive tender than at any other point in its journey from the mine to the ash pan. Considering a great majority of the locomotives in this country, which are easily within the capabilities of hand firing, and placing the limit at possibly two tons of coal per hour burned, we know that there is an enormous amount of waste, and in most cases needless waste, going on all of the time.

The qualifications of a good fireman are, first, intelligence or brightness and, secondly, physical strength and endurance. In a great majority of cases no large amount of strength is required for proper firing, in itself, and that factor enters into this problem, the same as it does in all similar lines of activity, only when the action is constant and continued for a long period of time. Even then we find that the best firemen are not usually those who can raise the heaviest weight, but rather the men of moderate strength and great endurance. They are the fellows who fire properly and keep everlastingly at it. Your strong man will handle more coal and work harder; will be exhausted and require a longer period of rest, all because he has performed much useless labor and incidentally has needlessly thrown away a large amount of valuable coal. Comparisons between the small wiry chap, who uses his head, and the big strong fellow, who heaves coal, are present at every division point in this country and almost universally result in the favor of the former, provided, of course, he has been given the proper instruction.

The results that can be obtained from the education of firemen have been most thoroughly discussed in the columns of this and other technical journals, as well as in papers before societies and clubs, but apparently have not been sufficiently impressive to cause the introduction of a practical course on most of our railways. A few of the companies are furnishing their men with literature going more or less fully into the theory of combustion and giving detailed instructions as to the proper method of firing, and still fewer have followed this up with a thorough course of individual instruction, but a very great majority have done neither and practically allow a new fireman to learn his business as best he can from his associates.

On divisions where the proper grade of men can be obtained and the work of instruction is systematically and conscientiously followed out, most gratifying results, in the shape of improved fuel records, increased interest in the work, and a contented and loyal set of firemen, are possible. Upon the other hand where either a low grade of men is all that is available, or where the work of instruction is done in a half-hearted or slip-shod way by incompetent instructors, the education of the firemen is bound to be a failure in all ways. There will always, of course, be individual cases that it will be impossible to do anything with. These will usually be found to be confined to the man with a strong back and a weak head (which some one has facetiously stated should be the qualifications of a fireman), who can get over the road because of his strength, but cases of good firemen quitting because they could not stand the work, which was easily within their strength if they had been properly instructed, are not by any means uncommon throughout the country, and it is this feature that causes the greatest regret that more attention is not being given to the subject of education. If you cannot get firemen of sufficient intelligence it is unfortunate, but if you don't keep those who are capable of learning, there is certainly a grave fault somewhere.

The lines that should be followed in educating the firemen are covered in a general way in a previous section of this article. As far as the actual placing of the coal on the fire is concerned they consist very largely in convincing the men, both by sound reasoning and actual example, that it will pay, and pay well, to scatter well broken coal in small amounts on various parts of the grate in succession, with such an interval between charges as will make it necessary to again cover the first point as soon as the whole grate area has been gone over. This, of course, with the ordinary locomotive, means continuous, but in most cases leisurely, work and gives no time for the seat box or anything else while the locomotive is working at full power. Opportunities for the needed rest will be given on the down grade stretches, the stops for water, the waits at meeting points or for orders and the shut-offs for signals, flags, etc. This is the way firemen should fire and the way an intelligent educated fireman will fire *provided* he is not expected to take care of ten or fifteen other things at the same time. He cannot and will not do it if he has to break all of his coal; if he has to climb up and shovel it down from the back of the tender every half hour or so; if he is expected to see every signal; if he has to clean out the ash pan at every stop for water; if he has to work against an injector that "forgets" or a couple of extra notches on the quadrant; if he is given dirt and slack for coal; if the competitive coal records are based on the guesses of an ignorant coal chute hand; if the records are posted six weeks after they are made; if an engine rated at 2,000 tons is habitually given 2,200 tons, etc., etc.

The education of firemen will pay if it is given a chance, but there is no use in teaching a man to do a thing properly and then arranging conditions so that it will be impossible for him to do it that way. Give a fireman a small shovel, not over 15 lbs. capacity, an automatic door opener and decent coal; teach him how to fire and if he is not loaded down with other duties and handicaps you will be surprised how little coal he will burn per ton mile or per car mile, as well as in the reduction of engine failures due to leaky flues and fire-boxes.

Of course there are many conditions affecting the efficiency of the firemen over which the motive power department has no control, and many others over which no one has control, all of which tend to neutralize the value of the properly educated fireman. But there are enough which can be controlled to make it very advisable to accompany a scheme of training firemen with a course of education and improvement along other lines. It is not an impossible condition to find master mechanics and even higher officials who are in need of a little educating in things which directly concern the firemen and the fuel bill.

There is one condition, however, which no amount of training or education will improve, and that is a locomotive of a size and power which no man can shovel coal enough into, properly or improperly, to develop its capacity. This would also include those locomotives which are capable of hand firing, only when everything is in perfect shape, and fall down under ordinary adverse conditions. At the present time there is no very large number of locomotives running in this country which would come strictly under this head and if we had only to consider these, there would be no great demand for mechanical stokers. There are, however, a large number of big engines which, from causes beyond the mechanical department's control, and seemingly incapable of correction, a few of which have been mentioned, are not able to give their full power with hand firing.

At some points it is impossible to get men for firemen who are of a sufficiently high order of intelligence to be able to learn to fire properly and economically. This may be due to a poor source of supply; to a rush of business compelling the acceptance of any one, or to working conditions and surroundings, which no self-respecting man will put up with. No matter what may be

the cause of their presence such men will not be able to develop the full power of a big locomotive over a division of average length.

Again it may be very desirable, and possibly profitable, to use a grade of fuel which is so high in ash and impurities as to compel a man to get it into the fire-box as fast as he can, so as to have time to shake the grates. He certainly cannot properly develop the power of the locomotive under these conditions, even if the fuel is capable of doing it at all.

Thus there are four conditions which are beyond correction by the proper education and training of the firemen, and even beyond correction by the mechanical department. These are,—very large locomotives; operating conditions making proper firing impossible; low grade of men and use of low grade fuels. Under such conditions we are compelled to look to a mechanical device if we are going to get out of our locomotives all that is in them for the whole length of a long division.

There are also many conditions which seem to indicate a pressing need for the mechanical stoker, but which are within the control of the mechanical department, and can be solved much better in other ways. These have been touched upon more or less fully above.

For the purpose of getting an idea of the actual state of affairs in respect to how general and insistent a demand for mechanical stokers exists, a letter was sent to about seventy-five motive power officials asking their opinion on the subject, and the reasons therefor. The letter also asked for an account of any experience that they may have had with mechanical stokers.

The answers as a rule were perfunctory and indicated that while a large majority thought a mechanical stoker was badly needed, the conditions were not serious enough to cause any special efforts being made to alleviate them, in any other way, while awaiting the perfection of a satisfactory stoker. Quite a number had given the subject more careful study and basing their deductions on the conditions existing on their own lines arrived at some very sensible and definite conclusions.

One motive power official who is well known for his clear-cut opinions on big subjects, writes as follows:

"As far as we are concerned we do not at present feel the need of the mechanical stoker on locomotives, unless its adoption should result in a general and substantial saving in fuel. It is possible that the application of a mechanical stoker to all our engines might do this, but my feeling is that the mechanical stoker can at present only represent average good firing and while it might give superior results to a poor fireman it could hardly be equal to the best.

"The question, however, arises as to whether the same amount of money spent in educating our firemen and following the matter up closely would not give equally as good results as the adoption of the mechanical stoker and possibly as good results could be obtained without as much money being spent. Anything we add to the locomotive, while it may appear simple and substantial, will ultimately mean expense for maintenance and occasional trouble from failures, and unless some real advantage is going to be gained from its use it will be a very questionable device to go into.

"While we have tried the mechanical stoker we have not so far had much success with it but I do not consider that the small number used has much to do with the stokers not working satisfactorily, but more on account of attention to the stoker not being worth the trouble when all things are considered.'

An answer from a road which burns oil on some of its divisions and hence has been able to observe the result of comparative idleness on the labor situation is in part as follows:

"What does the railroad gain by going to the expense of installing stoker equipment when already firemen are being paid (enough surely) to do this work? It has been my observation in a general way that only those men whose time and whose efforts are pretty fully taken up actively, are contented and would produce the best results. As an instance I may cite the case of firemen on coal burning locomotives as compared with firemen on oil burning locomotives: the former have to do a fair amount of pretty hard work to hold their jobs and the troubles in dealing with these men are due chiefly to the fact that most of them are quite young and have the rash impetuosity and hot headed devil-may-carelessness of youth; the latter has practically nothing to do but to sit on his spring seat cushion, occasionally touch the valve levers controlling the fuel oil, air, and steam supplies, and semi-occasionally funneling a little sand through the fire door for the purpose of scouring out carbon and sediment deposits in the flues—he does not have to work so hard nor be so skilful as the engineer, and in fact has practically nothing to do but gaze out upon the burning desert wilds and think of his troubles. As a class, the oil-burning firemen are overpaid, are discontented, giving unsatisfactory service, are grossly wasteful of fuel and ready to seek any excuse to shirk some portion of their duties; and their agitators and committees give constant trouble.

"Would not the general application of the mechanical stoker, with its relief to the fireman of the only real work he is called upon to do, similarly serve to produce an unsatisfactory labor condition? The coal firemen have to work so hard that only the fittest and most persistent can stay by the job; in this way we get a pretty good type of manhood for filling the later responsible positions as engineers; would this be the case if physical prowess was no longer a requisite for fireman's service?

"Would the mechanical stoker give economy in fuel? I doubt it just from such examples of automatic stokers applied to stationary practice as I have seen. The mechanical stoker would be apt to give considerable trouble in repair and attention and I venture to say that it would add another fruitful source to the many producing engine failures. These repairs, moreover, would probably be quite costly at the year's end, taking ordinary railroad conditions as the criterion.

"In general, of course, the question of fuel is a very important one, in fact it is the most important consideration of all our immense industrial life and it is the largest single item of expenditure making up the cost of operating American railways, amounting, as it does, to approximately 10 per cent of the operating expenses. It is not too much to say that if this matter was followed up very carefully, and practically perfect conditions of combustion were secured, on each and every engine of a railway, the total cost of fuel could be reduced one half.

"While I would regard the mechanical stoker as not practical under ordinary American railroad conditions to-day, I do believe that such a device would have a limited field of usefulness as applied to some of our very largest engines in the very hardest service, *e. g.*, pusher engines of the Erie Mallet type (which now require two firemen)."

Two roads running west from Chicago reply as follows. One of these has a large number of "big" engines in both passenger and freight service. The other does not use very large locomotives in either service.

"I do not regard the need for a locomotive stoker as particularly urgent as we find it possible to get along pretty well without it. The stoker question is attractive however to some railroads which find it necessary to burn inferior grades of coal, which might be burned more satisfactorily by the use of a stoker."

"With the size of locomotives in use on this road I do not believe there is any real necessity for a locomotive stoker, although probably on some of the larger power this may be necessary. As I understand it, the men the stoker was designed to benefit are the principal objectors to using it, and where it has been tried it is my information that they have been the means of knocking it out. This is only hearsay, but I believe it is correct."

Replies from two Southern roads indicate the poor grade of labor in that section creates a demand for mechanical stokers which would not be present on the same locomotives in the Northern States:

"With the large modern engine and the work that is required of it, we have about reached the limit of human endurance in firing a locomotive, and it would be extremely desirable to use a mechanical stoker, if it was possible to design one that would deliver the coal to the grates in proper quantities and properly distributed. So far as I know, the reason that stokers are not generally used is due to the fact that as yet there is not a stoker that will do the work properly. We made quite an extended test of two stokers on our lines, under the personal supervision of our road foreman of engines and our engineer of tests and were unable to accomplish the desired results. The Pocahontas coal which we use is a very high grade coal, and it is my opinion that if these stokers would not work with that grade of coal which we are using, it cannot be expected to give satisfactory service from the average grade of coal furnished to the various roads of this country."

"I am thoroughly convinced that a mechanical stoker for locomotives is desirable. In the first place the size of our engines is such that it is almost impossible to obtain firemen of the requisite intelligence for handling them; the only class of labor that we can obtain, on account of the extreme drudgery of the work, is such as lack the intelligence to develop ultimately into suitable engineers."

Other interesting opinions from various sections of the country are given below.

From a road in the middle South:

"With wide fire box engines it is our observation that the mechanical stoker is not needed, as we find that one man can fire an engine hauling 4,000 tons of freight over a 120 mile division with a wide fire box, where it is out of the question for him to do so with a narrow and long fire box—all other dimensions of the engine being the same."

From a road running east from Chicago:

"I believe that there is a need for a mechanical stoker on locomotives, especially is this so in warm weather. We had quite a number of locomotive firemen on our large consolidation engines overcome with the heat last summer. We believe a good design of mechanical stoker would avoid this, as well as show an economy in the consumption of fuel.

"Our experience, with stokers tested, indicated that there were two objections: One, mechanical defects in the stokers causing them to fail: the other, the mechanical stoker which we had experience with occupied

practically all the room on the deck and had to be removed on each failure in order to hand fire the engines. This stoker when in good working order would fire any locomotive we had on our road and would do it successfully, and we believe more economically than the firing could be done by hand. But for the reasons named and the further reasons that we only had a half dozen of them in service we could not get as satisfactory service under these conditions as we could with hand firing. I would suggest that where mechanical stokers are introduced that they be applied to all the engines on the same division.'

Another road in the middle West:

"During the past four years the scarcity of labor has made it very apparent that there was necessity for some proper device for feeding of coal in fire boxes of locomotives. In a great many cases it has been necessary for railroads to employ firemen who were not of a satisfactory weight or intelligence to handle the work required of a fireman on our modern type of locomotives and from whom we could not expect to get competent enginemen. The work of the firemen is becoming so arduous on the larger type of locomotives that any man with any degree of education will not seek this class of employment, but goes into other channels where the duties required are less taxing on their strength and for which they get a better return. As a result of this condition we must expect a natural decline in the quality of our enginemen and in view of the above facts I feel that the necessity for a satisfactory stoker is very apparent."

A road running out of Pittsburg states:

"We have never used mechanical stokers and at this time hardly think they are a necessity, but as engines increase in size they are bound to be, and it would seem to me that the production of some efficient stoker should be encouraged as much as possible."

A far Western road replies:

"We do not believe that there is a very urgent need for stokers as our firemen are able to handle our present locomotives without any trouble."

From a Southern system:

"There is at present in this country the most urgent need for a reliable mechanical stoker on locomotives. The rapid development of heavy power has made the duty of the locomotive fireman so exacting that we find it very often to be the case that the man is unequal to the duties imposed upon him. Railroads must perforce recruit their engineers from the firemen's ranks. For this reason it is necessary that the firemen be men of some brain, as well as brawn. Of course the strong mind and the strong back may be sometimes found together, but it is a little bit unusual, and the strong mind is not hunting—as a general proposition—for such laborious occupations as locomotive firing has become. I am aware of instances of heavy power being run in this country under tonnage rating, for the reason that one fireman cannot maintain the maximum steam pressure and handle full ratings on the schedules involved."

From a road running west from Pittsburg:

"The necessity for a mechanical stoker for locomotive purposes is urgent, and while saving in fuel is, of course, an important item, if a successful stoker is developed and no fuel saving effected, the demand for its application is still urgent.

"1st. On account of smoke ordinances which all of the large cities are enforcing, which may compel the railroads to use a very expensive fuel. The uniform firing with a mechanical stoker will greatly reduce, if not entirely overcome complaints on account of smoke.

"2nd. In the selection of firemen to-day, on account of the more arduous character of the work, we are practically hiring a man on account of his capacity for physical endurance. The mechanical stoker, by reducing the requirement on this account, should enable us, to some extent, to pay more attention to intelligence.

"3rd. A successful mechanical stoker should reduce to some extent flue leakage troubles.

"4th. It should permit the use of commoner and cheaper grades of fuel.

"5th. The possibility of saving in fuel."

The chief lesson that can be drawn from these letters is that, whether there is an actual need for stokers or not, there is, beyond doubt, a demand for them.

Mechanical Stokers.

As is stated in one of the letters above, all that can be expected of a mechanical stoker is to equal average good firing. It cannot be expected to equal the best hand firing, but must, of course, do better than a poor fireman. This, however, is but one of the conditions which a successful mechanical stoker must meet, although of course it is the most important, but a stoker which is to receive general adoption must also possess a number of other very important features. In the first place it must be absolutely reliable. No railroad company can afford to put anything on its locomotives which has any possibilities of causing an engine failure. Again, a satisfactory stoker must be comparatively noiseless. There is already sufficient racket in the cab of a locomotive to make communication between the engineer and fireman somewhat difficult and it will not do to increase this to any appreciable extent, and thus make such communication practically impossible. In addition to this any great addition to the noise on a locomotive is going to make it extremely difficult for an engineer to hear torpedoes. Another desirable feature is that the stoker should take up as little room as possible. It should further consist of the fewest possible number of parts and have no delicate mechanism. It should also be arranged so as to permit a quick and easy change to hand firing in case such a move becomes necessary.

In addition to these strictly mechanical qualifications a stoker must be able to show a direct saving which will at least pay the interest on its cost, a liberal rate of depreciation and all charges for maintenance. Such a saving can be made in several ways, either by improved combustion, leading to the use of a smaller amount of fuel; by the use of a lower grade fuel, due to the stoker's ability to fire properly; to the opportunity of operating large engines over divisions of a length which exhaust a good fireman and lead him to waste coal by improper firing on the latter end of his run; by the reduction of leaky flues and fireboxes directly due to the proper firing; to the reduction of the smoke nuisance in large cities, owing to the better condition of combustion and possibly also the ability to hold a better grade of men.

While practically all of the designs of mechanical stoker, which have so far been given practical trials, have sought to simulate hand firing, accomplishing this by several different methods, there are designs now in the process of evolution which seek to accomplish the desired result in other ways. One of these is an underfed type in which the coal is forced up from below and is burned by means of the forced draft; this permits the elimination of the vacuum in the front end and thus a considerable reduction in back pressure on the cylinders. This type of stoker is claimed to be capable of burning very low grade fuel, giving practically complete and smokeless combustion.

Another arrangement which has been suggested, and is being worked out, which also presents possibilities for use of extremely low grade fuels, is a stoker, in which the fuel is pulverized and blown into the fire-box through a jet, burning much the same as oil. Properly arranged this stoker should be able to give practically perfect combustion.

Both of these types, however, have not yet reached the stage at which their inventors are able to report anything more than bright prospects.

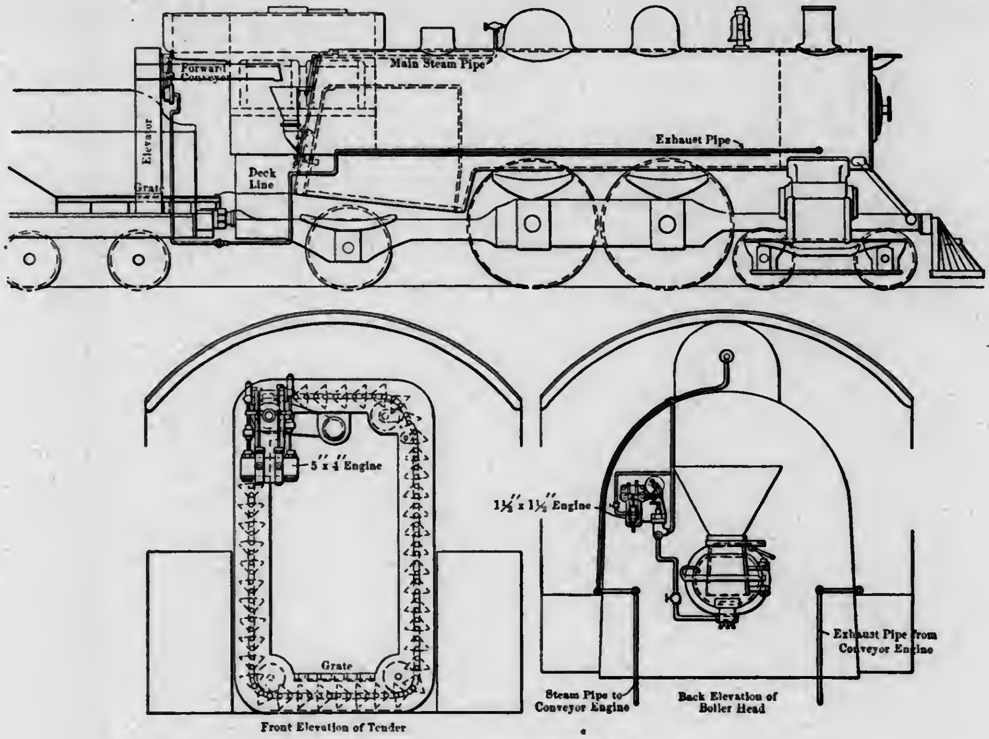
The stokers which imitate hand firing can be divided, roughly, into three different types, one in which the coal is thrown on the different parts of the grate by means of a plunger, a deflection plate being used to govern the direction. Another blows the coal to different points on the grate by means of air or steam jets and the third type uses a revolving fan arrangement, the wings of which throw the coal through a spout, which is capable of adjustment to determine the point on the grate which shall be reached.

In all of these types the principles of correct hand firing are followed out, that is, that a small amount of well broken coal is scattered in either a thin layer over certain separate sections or small pieces miscellaneously over the whole area of the grate. In the former case the different sections are covered in succession, with such a time interval as to make the action of the stoker continuous while the engine is working at full capacity. The best examples of each of these types incorporate a conveyor from the tender to the hopper, forming part of the stoker proper, thus permitting the fireman to devote his entire time to watching the condition of his fire, shaking the grate, and assisting in keeping a lookout ahead.

There is one design of each of these types which has proven itself to be successful in practical service, and while not even the designers claim that perfection has been reached, still we have three designs of mechanical stokers which have proven themselves capable of properly firing locomotives now in service in this country, each being designed on a different principle.

HAYDEN MECHANICAL STOKER.

This stoker is of the type wherein the coal is blown in small amounts on to the grate by means of a steam jet. It has proven



DIAGRAMS SHOWING APPLICATION OF HAYDEN MECHANICAL STOKER.

itself to be thoroughly practical and has been in service on one locomotive on the Erie Railroad for about a year and a half. The construction of the device is clearly shown in the illustrations, from which it will be seen that the fireman is relieved of all hard labor and that when the stoker is once set properly it is practically automatic, while the operation of the locomotive remains the same.

The stoker proper is accompanied by a conveyor which is mounted upon and forms part of the locomotive tender. This conveyor is of such a size and shape that it can be placed between the water legs of the tank with the lower part flush with the bottom of the coal space. It consists of a series of buckets mounted on an endless chain surrounded by a casing. The travel of the buckets lifts the coal and dumps it into a horizontal trough, which extends inward to the hopper on the boiler head. This trough is of a sufficient height to clear the head of a man working underneath and carries a spiral conveyor. The coal inlet at the bottom of the bucket conveyor is covered by a grate having openings 3 in. square. The coal is raked into these openings and is carried by the buckets across and up the right side, then horizontally to the trough, where it is automatically dumped and the empty buckets descend on the other side. The conveyor is driven by a small duplex steam engine mounted on its casing and controlled by a throttle valve on the engine.

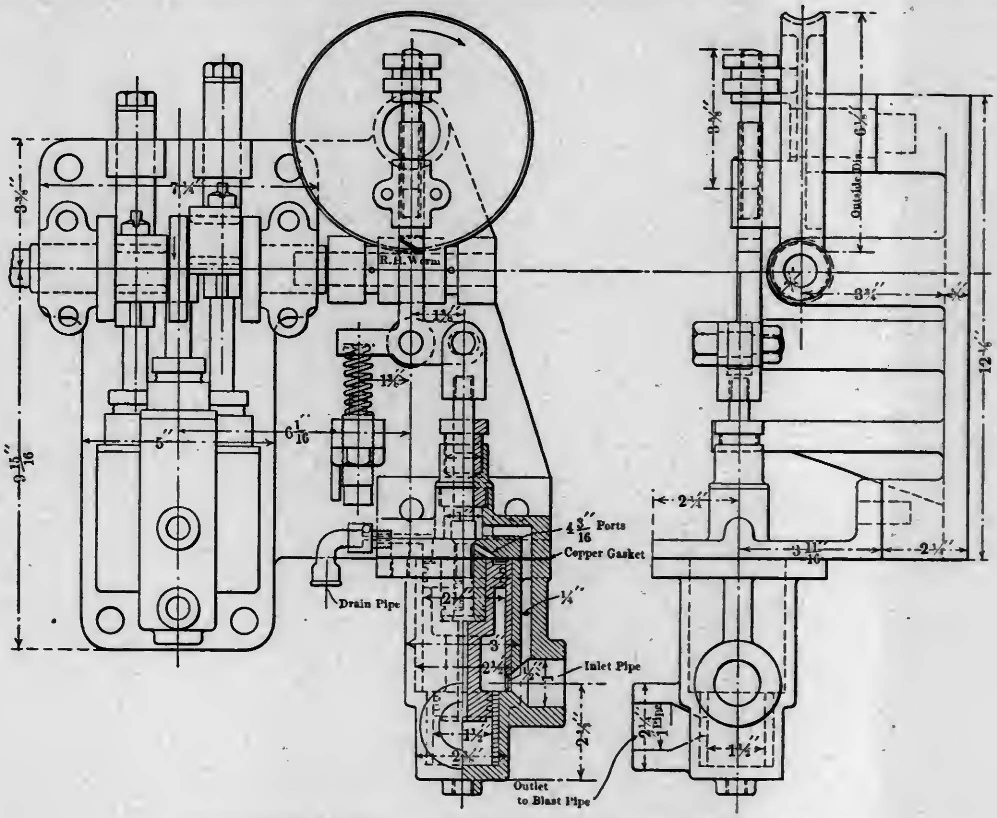
The stoker proper is composed of a narrow shelf bolted on the inside of the fire-box level with the bottom of the door opening and protected by a carborundum facing on the bottom and sides. The ordinary fire door is removed and for it is substituted a door having a chute leading through it, with its upper edge projecting over the shelf just mentioned. An adjustable plate by which the size of the opening can be varied is provided. This door is hinged to the frame in the usual manner and can be opened for hand firing if desired. A hopper which receives the coal from the spiral conveyor is bolted to the boiler head above the door opening and discharges directly into the chute in the door. A sliding gate operated by a rack and gear by which the supply of fuel can be cut off or adjusted at the hopper, is provided. There is no connection between the hopper and the door.

A blast pipe, consisting of a series of jets, is placed in the bottom of the fire door opening on the level with the top of the shelf and the jets are directed in such a manner as to throw the fuel to all parts of the grate. Each jet is provided with a valve, so that the flow of steam through it may be regulated independently of the flow through the other jets. These jet valves are mounted on a manifold that is connected by a pipe to the blast valve. A globe valve in this pipe controls the force of the blast as a whole.

Instantaneous opening and closing of the blast is required, and the blast valve, which is shown in detail in one of the illustrations, is constructed so as to obtain this result. It consists of a main valve, an auxiliary valve and the proper ports combined in a casing so that a slight movement of the auxiliary valve will instantly operate the main valve through its full movement. The manner in which this is done is clearly evident from a study of the illustration. The auxiliary valve is connected to a bell crank, which is tripped by a finger carried on a revolving disc, which in turn is driven by a worm revolved by a small engine which can be throttled to give the desired speed for the number of blasts required.

The operation of the device is as follows: The fuel which is fed into the hopper by the conveyor flows by gravity through the chute in the door and rests in a pile on the shelf in front of the jets. The size of this pile of fuel is determined by the position of the plate at the mouth of the chute. The fuel being fed continuously through the hopper and chute forms an air seal and preserves the draft in the furnace. The jet valves are throttled so that when the blast operates, the fuel is thrown to all parts of the furnace and scattered evenly over the fire. The intensity of this blast is dependent upon the draft conditions in the furnace. The duration of the blast is controlled by means of an adjustment of the trip finger, which operates the auxiliary valve by means of the bell crank lever and thus holds this valve open for a varying period of time. The usual period of blast is about one second. The speed of the conveyor engine determines the amount of coal that is fed to the hopper and can be varied to suit the conditions. For very light firing the stoker is able to place two or three pounds of coal at one charge as often as may be desired, and for ordinary heavy firing it can place ten pounds of coal per charge with a blast of from 1½ to 2 seconds duration, operating seven times a minute. If desired, the blast can be made continuous and as much coal as the conveyor will deliver can be put on the fire. This condition of course is beyond the requirements of any service.

This stoker is manufactured by the N. L. Hayden Mfg. Co., Columbus, Ohio.

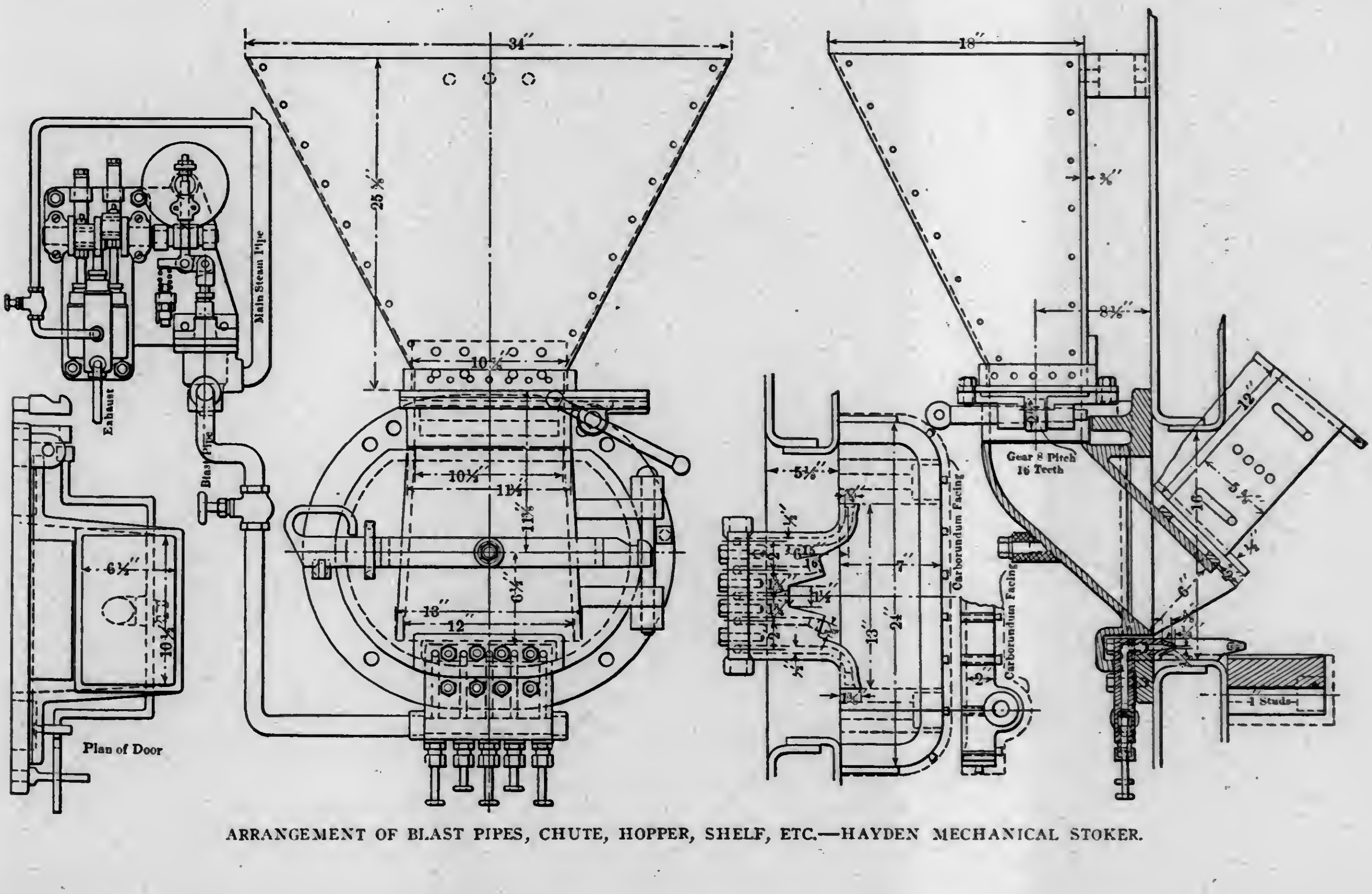


BLAST VALVE AND ASSOCIATED APPARATUS—HAYDEN STOKER.

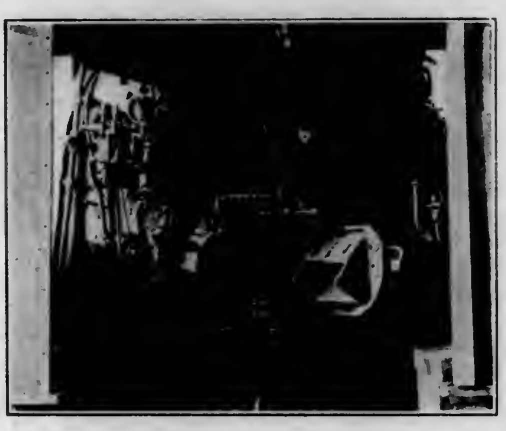
CROSBY MECHANICAL STOKER.

This stoker is of the revolving fan type, in which the coal is thrown into the furnace by means of the wings of a fan and is located by the automatic adjustment of the chute on the inside of the fire door, which directs the coal to the point desired. For the purpose of description, it can be divided into three separate parts: the first consisting of the apparatus which carries the coal from the tender to the stoker proper; the second, the propelling apparatus which forces the coal into the fire-box, and the third, the guide chute which directs the stream of coal to different points on the grate.

The first step is obtained by means of a screw conveyor extending from the rear of the coal space in the tender to the fire door and running in a sheet metal trough with a circular bottom and flaring sides. This conveyor is in two parts, one section extending from the back of the coal space to a point just in front of the coal gate, where both the spiral and the trough are joined to the inclined section, in a manner which provides perfect free-



ARRANGEMENT OF BLAST PIPES, CHUTE, HOPPER, SHELF, ETC.—HAYDEN MECHANICAL STOKER.



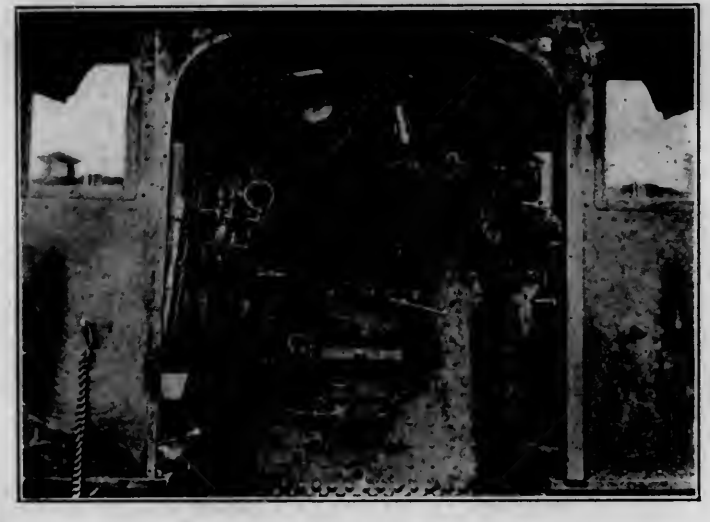
HAYDEN STOKER—CHUTE INSIDE FIRE DOOR.

CONVEYOR ARRANGEMENT ON TENDER—HAYDEN STOKER.

ness for adjustment to the relative movement between the locomotive and tender and also to allow the inclined section to be thrown back against the coal gate when not in use. The section in the bottom of the tender is covered from its rear end to within a few inches of the coal gate by plates about a foot long. These plates are removed one by one as the coal pile gets further back in the tender. This conveyor is driven from the same source of power as are the revolving blades, but is provided with a cone gear arrangement which permits it to have a variable speed. A lever, conveniently placed, controls the speed or the starting and stopping of the conveyor by the fireman. The gears are enclosed in a case, which will be noticed in the diagrammatical view as hanging beneath the inclined section.

The conveyor will handle lumps of coal up to about 10 or 12 in. in size, bringing it up to where the fireman can conveniently reach it and break it up into small pieces with an ordinary machinist's hammer.

The conveyor discharges the coal into a small receiving hopper, where the rapidly revolving blades gather it and discharge it through a round nozzle in the door. These each discharge one-half of the receiving hopper, being offset for that purpose, and run at a constant speed while in operation. The receiving hopper forms part of the casting, which is bolted to a specially designed door, replacing the regular fire door. Alongside of it is a steam tight chamber in which is mounted a steam turbine disc upon which four small steam jets impinge. The turbine wheel and rotating blades are mounted on one shaft, which at the turbine end projects through the bearing and carries a fly ball governor mechanism, which operates the steam valve and provides an automatic constant speed arrangement for the blades. The opposite end of this shaft projects beyond the case and carries a worm which drives a worm gear, all being contained in an oil tight case bolted to the frame. The worm gear shaft provides the motion for the screw conveyor. It also, on the opposite end, carries a small worm meshing with a gear, which further reduces



HAYDEN STOKER WITH CONVEYOR REMOVED.

the speed and drives the mechanism controlling the motion of the spreading chute, which directs the stream of coal in the fire-box. This small worm may be engaged or disengaged from the shaft by a small lever and thereby stop the spreader at any point in

GENERAL VIEW OF CROSBY STOKER READY FOR SERVICE.

its cycle and build up the fire where it may need special attention.

The spreading arrangement automatically passes through a cycle

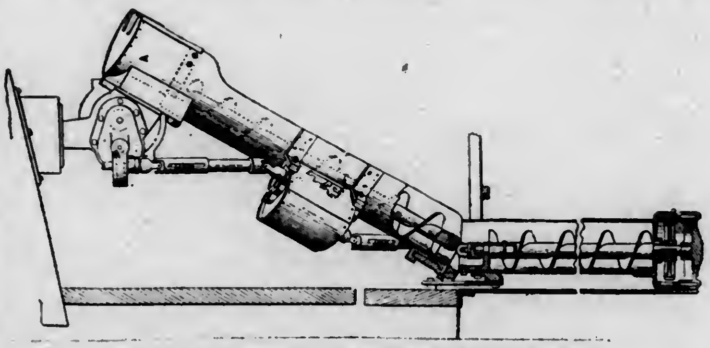
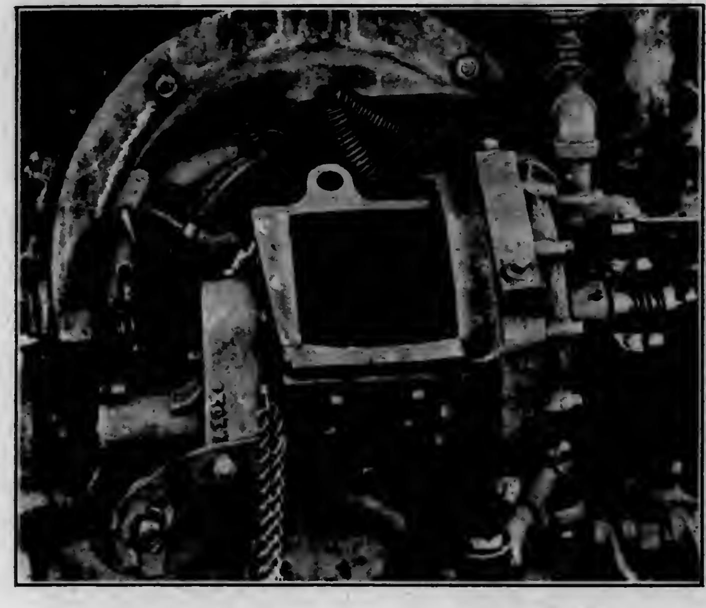


DIAGRAM OF SPIRAL CONVEYOR—CROSBY STOKER.



CROSBY STOKER—APPARATUS ON FIRE DOOR.

SPREADING DEVICE—CROSBY MECHANICAL STOKER.

of movements which accomplish the following results: The thin stream of coal issuing from it is distributed in a thin layer over a strip one-third of the width of the fire-box down the left side, starting from the flue sheet and extending back into the back corner; then with a quick movement the spreader starts at the flue sheet in the center of the fire-box and distributes coal over the center one-third of the width; then quickly moves to the front right corner and down the right side, including the back corner, then transfers again to the front left corner and repeats the cycle. This motion is entirely automatic, but can be interrupted at any point, as above mentioned.

In case of necessity this stoker can be disconnected and put out of the way and permit hand firing to be started in the usual manner within a space of thirty seconds. The total weight of the stoker and conveyor is about 900 lbs.

The work of developing this stoker was all done on the Chicago & Northwestern Railroad, where it, after a certain series of preliminary experimenting had been completed, showed itself to be entirely reliable. It is being built by the International Stoker Company, 181 La Salle street, Chicago.

STROUSE MECHANICAL STOKER.

This stoker is an example of the plunger type, being an evolution from the pioneer locomotive stoker which was known as the Kincaid. It, of course, differs from that design in practically all its features, but is built on the same general principle. It consists, briefly, of a horizontal plunger mounted in guides and operated by a steam cylinder. This plunger carries at its forward end a special shaped nose, which is arranged to discharge the coal on different parts of the grate, depending upon the speed with which it is operated. The forward stroke of the plunger throws the coal to the center, or the front ends of the grate, and the backward stroke, by means of a special shape of the nose, places the coal in the back corners and beneath the fire door.

The coal is discharged into a large hopper by means of the conveyor, which is not shown in the illustration, from which it falls upon a shelf directly in front of the plunger nose. The fire door opening is provided with a specially designed door, hinged at the top and forced open by the plunger on its forward stroke. The whole apparatus, except the special fire door, is mounted on a framework, supported by small wheels, which is secured to the fire door ring by two slotted lugs with keys, and also by two suspension turnbuckle rods, which hook into eyes on the boiler head.

The length and intensity of the stroke of the plunger are governed by levers, shown at the left side, which are operated by the fireman.

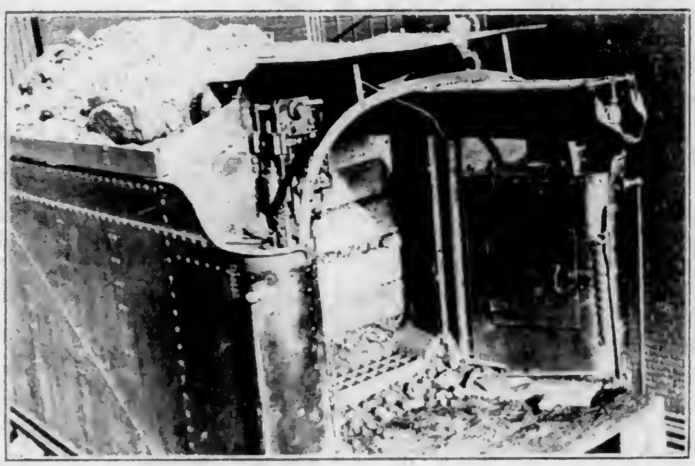
This stoker has been applied to a number of locomotives on the Iowa Central Railroad and is manufactured by the Locomotive Stoker Company of Chicago.

STROUSE MECHANICAL STOKER IN POSITION IN CAB.

BRIQUETTING.

The possibility of obtaining a most satisfactory and high grade fuel for use on locomotives through the medium of briquetting grades of fuel which are now of no practical value, and are usual-

HAYDEN STOKER—CHUTE INSIDE FIRE DOOR.

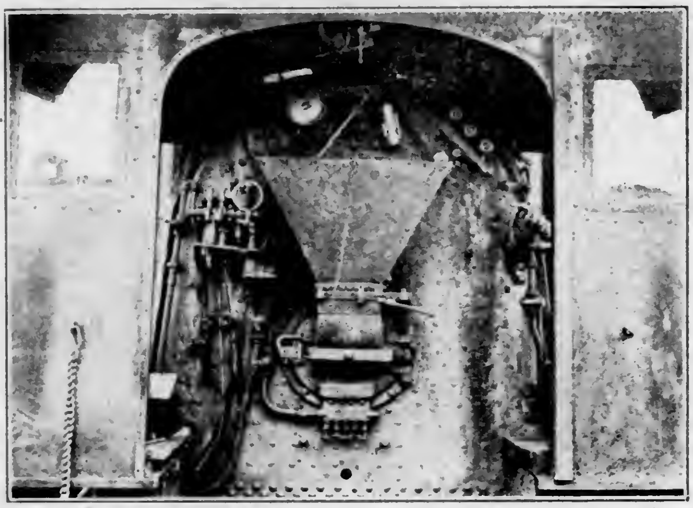


CONVEYOR ARRANGEMENT ON TENDER—HAYDEN STOKER.

[illegible] adjustment to the relative movement between the locomotive and tender and also to allow the inclined section to be thrown back against the coal gate when not in use. The section in the bottom of the tender is covered from its rear end to within a few inches of the coal gate by plates about a foot long. These plates are removed one by one as the coal pile gets further back in the tender. This conveyor is driven from the same source of power as are the revolving blades, but is provided with a cone gear arrangement which permits it to have a variable speed. A lever, conveniently placed, controls the speed or the starting and stopping of the conveyor by the fireman. The gears are enclosed in a case, which will be noticed in the diagrammatical view as hanging beneath the inclined section.

The conveyor will handle lumps of coal up to about 10 or 12 in. in size, bringing it up to where the fireman can conveniently reach it and break it up into small pieces with an ordinary machinist's hammer.

The conveyor discharges the coal into a small receiving hopper, where the rapidly revolving blades gather it and discharge it through a round nozzle in the door. These each discharge one-half of the receiving hopper, being offset for that purpose, and run at a constant speed while in operation. The receiving hopper forms part of the casting, which is bolted to a specially designed door, replacing the regular fire door. Alongside of it is a steam tight chamber in which is mounted a steam turbine disc upon which four small steam jets impinge. The turbine wheel and rotating blades are mounted on one shaft, which at the turbine end projects through the bearing and carries a fly ball governor mechanism, which operates the steam valve and provides an automatic constant speed arrangement for the blades. The opposite end of this shaft projects beyond the case and carries a worm which drives a worm gear, all being contained in an oil tight case bolted to the frame. The worm gear shaft provides the motion for the screw conveyor. It also, on the opposite end, carries a small worm meshing with a gear, which further reduces



HAYDEN STOKER WITH CONVEYOR REMOVED.

the speed and drives the mechanism controlling the motion of the spreading chute, which directs the stream of coal in the fire-box. This small worm may be engaged or disengaged from the shaft by a small lever and thereby stop the spreader at any point in

GENERAL VIEW OF CROSBY STOKER READY FOR SERVICE.

its cycle and build up the fire where it may need special attention.

The spreading arrangement automatically passes through a cycle

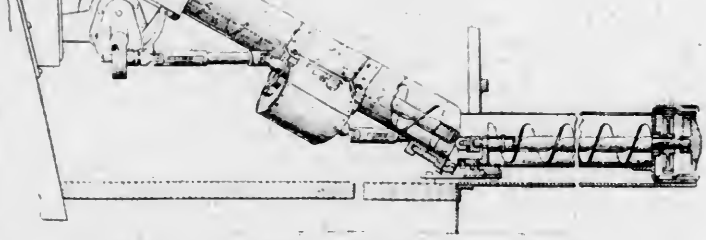
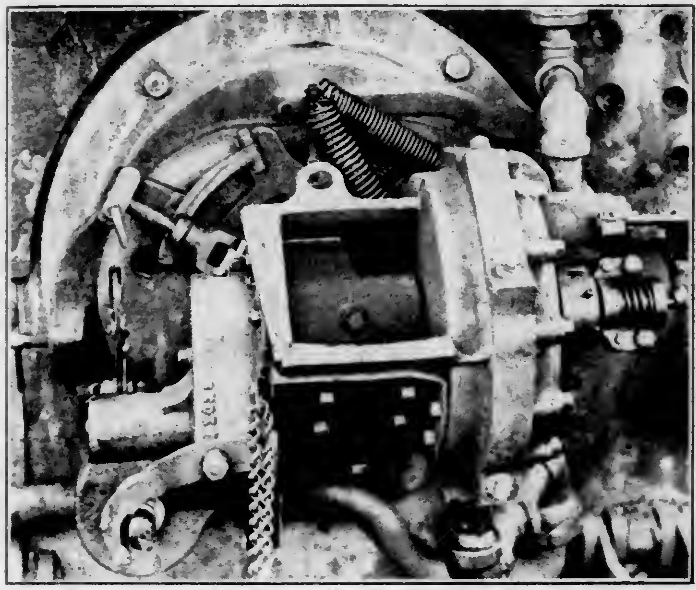
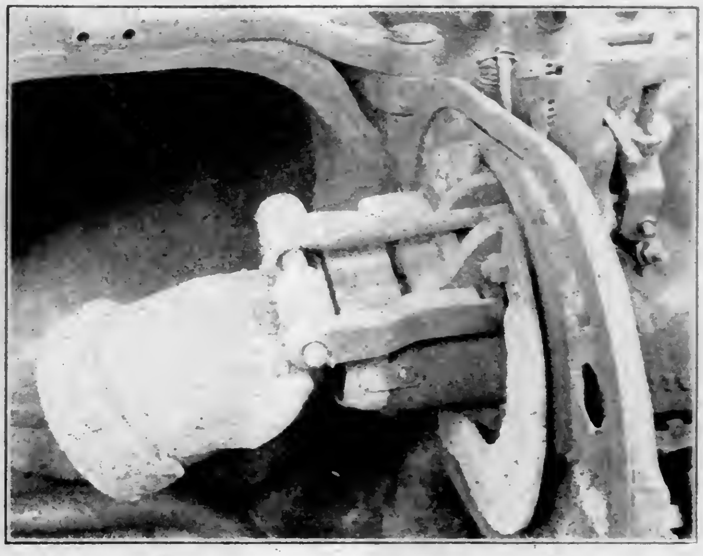


DIAGRAM OF SPIRAL CONVEYOR—CROSBY STOKER.



CROSBY STOKER—APPARATUS ON FIRE DOOR.



SPREADING DEVICE—CROSBY MECHANICAL STOKER.

of movements which accomplish the following results: The thin stream of coal issuing from it is distributed in a thin layer over a strip one-third of the width of the fire-box down the left side, starting from the flue sheet and extending back into the back corner; then with a quick movement the spreader starts at the flue sheet in the center of the fire-box and distributes coal over the center one-third of the width; then quickly moves to the front right corner and down the right side, including the back corner, then transfers again to the front left corner and repeats the cycle. This motion is entirely automatic, but can be interrupted at any point, as above mentioned.

In case of necessity this stoker can be disconnected and put out of the way and permit hand firing to be started in the usual manner within a space of thirty seconds. The total weight of the stoker and conveyor is about 900 lbs.

The work of developing this stoker was all done on the Chicago & Northwestern Railroad, where it, after a certain series of preliminary experimenting had been completed, showed itself to be entirely reliable. It is being built by the International Stoker Company, 181 La Salle street, Chicago.

STROUSE MECHANICAL STOKER.

This stoker is an example of the plunger type, being an evolution from the pioneer locomotive stoker which was known as the Kincaid. It, of course, differs from that design in practically all its features, but is built on the same general principle. It consists, briefly, of a horizontal plunger mounted in guides and operated by a steam cylinder. This plunger carries at its forward end a special shaped nose, which is arranged to discharge the coal on different parts of the grate, depending upon the speed with which it is operated. The forward stroke of the plunger throws the coal to the center, or the front ends of the grate, and the backward stroke, by means of a special shape of the nose, places the coal in the back corners and beneath the fire door.

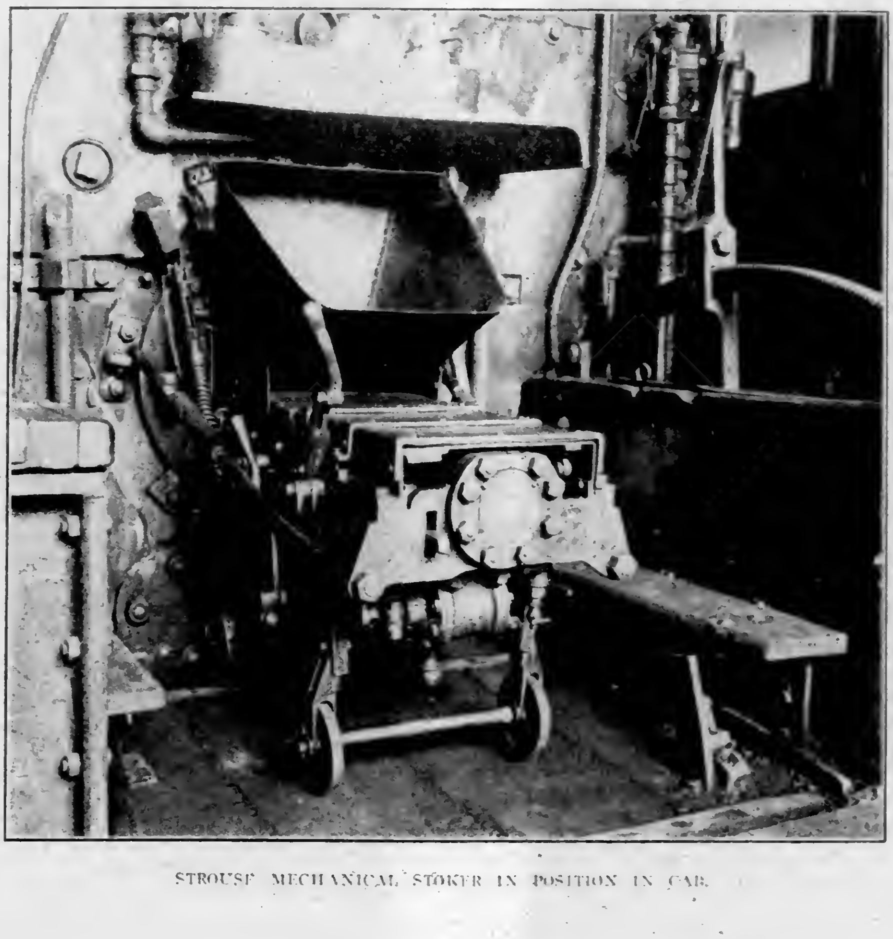
The coal is discharged into a large hopper by means of the conveyor, which is not shown in the illustration, from which it falls upon a shelf directly in front of the plunger nose. The fire door opening is provided with a specially designed door, hinged at the top and forced open by the plunger on its forward stroke. The whole apparatus, except the special fire door, is mounted on a framework, supported by small wheels, which is secured to the fire door ring by two slotted lugs with keys, and also by two suspension turnbuckle rods, which hook into eyes on the boiler head.

The length and intensity of the stroke of the plunger are governed by levers, shown at the left side, which are operated by the fireman.

This stoker has been applied to a number of locomotives on the Iowa Central Railroad and is manufactured by the Locomotive Stoker Company of Chicago.

BRIQUETTING.

The possibility of obtaining a most satisfactory and high grade fuel for use on locomotives through the medium of briquetting grades of fuel which are now of no practical value, and are usual-



STROUSE MECHANICAL STOKER IN POSITION IN CAB.

ly thrown away, is attracting a considerable amount of very active interest at the present time. Briquettes have been used in foreign countries with great success for many years and while the fuel conditions there are, of course, much different than hold in this country and make it absolutely necessary to utilize all grades of fuel, still the indications are that, even if there is no saving in first cost, the improved quality of fuel which can be obtained for the same price in the shape of briquettes will make them very attractive.

The government has undertaken a very elaborate series of tests on this subject, during which experiments with briquettes on locomotives in regular service have been undertaken on quite a number of the railways. The results are claimed to have been very satisfactory, but have not yet been given full publicity and we are unable at present to state authoritatively what the future possibilities along these lines may be.

The full report of these tests will be made within a short time and we will then again take up this subject.

THE CONSERVATION OF OUR NATURAL RESOURCES.

The next monthly meeting of The American Society of Mechanical Engineers will be held in the auditorium of the Engineering Societies Building, New York, on the evening of April 14. The general subject of the meeting is "The Conservation of Our Natural Resources," which is now receiving unusual attention, because of the invitation of the President of the United States to the governors of the several states, and to the presidents of the national engineering societies, to confer with him in Washington on this important problem.

The New York meeting will be addressed by four speakers, who will consider forest preservation in its relation to water power, *economy in the utilization of fuels*, and the attitude of the engineer in regard to these.

Dr. Henry S. Pritchett, president of the Carnegie Foundation for the advancement of teaching, will be one of the speakers and will discuss the "Relation of the Engineer to the Body Politic."

We will pay twenty-five cents each for copies of this Journal for January, July, September and November, 1903; October and November, 1906, and September, 1907.

"The coal record is kept on many roads a good deal, as the young bride kept her account book. On one page it said, Dear John gave me ten dollars. On the other page it said, Spent it all. On one page it says, Paid so much for coal at the mines. On the other page, The engines burned it up.—Mr. C. B. Conger, Traveling Engineers' Association.

"You have struck the nail on the head when you say to weigh the coal, but in order to get these appliances you must show your management where you are going to pay for the expenditure. When you do this you will get the coal-weighing appliances all right, as well as the measuring appliances and the blanks."—Mr. W. G. Wallace, The Traveling Engineers' Association.

"The following men are links in the chain that have not been considered in the performance sheet, and an important part of the organization left out entirely in the question of pounds of coal used per one hundred ton or car miles, when used only as a comparison of enginemen: The train dispatcher can, by good train movement, make the performance a profitable one for the company and creditable to himself, or, on the other hand, cause fuel to be burned unnecesarily; the trainmaster in ordering trains from terminals at the most advantageous time made up in proper order to avoid unnecessary switching; the conductor who can get over the road that we all like to pull either in passenger or freight service; the brakeman who looks after the leaks in train line and is alive; the station agent where freight is loaded as it should be and the switch list made out properly."—Mr. W. G. Wallace, The Traveling Engineers' Association.

(Established 1832).

AMERICAN ENGINEER AND RAILROAD JOURNAL.

PUBLISHED MONTHLY

BY

R. M. VAN ARSDALE

J. S. BONSALL,
Business Manager.

140 NASSAU STREET, NEW YORK

R. V. WRIGHT, E. A. AVERILL, } Editors.

APRIL, 1908

Subscriptions.—*$2.00 a year for the United States and Canada; $2.50 a year to Foreign Countries embraced in the Universal Postal Union. Remit by Express Money Order, Draft or Post Office Order. Subscription for this paper will be received and copies kept for sale by the Post Office News Co., 217 Dearborn St., Chicago, Ill. Damrell & Upham, 283 Washington St., Boston, Mass. Philip Roeder, 307 North Fourth St., St. Louis, Mo. R. S. Davis & Co., 346 Fifth Ave., Pittsburg, Pa. Century News Co., 6 Third St., S. Minneapolis, Minn. W. Dawson & Sons, Ltd., Cannon St., Bream's Buildings, London, E. C., England.*

Advertisements.—*Nothing will be inserted in this journal for pay,* EXCEPT IN THE ADVERTISING PAGES. *The reading pages will contain only such matter as we consider of interest to our readers.*

Contributions.—*Articles relating to Motive Power Department problems, including the design, construction, maintenance and operation of rolling stock, also of shops and roundhouses and their equipment are desired. Also early notices of official changes, and additions of new equipment for the road or the shop, by purchase or construction.*

To Subscribers.—*The* AMERICAN ENGINEER AND RAILROAD JOURNAL *is mailed regularly to every subscriber each month. Any subscriber who fails to receive his paper ought at once to notify the postmaster at the office of delivery, and in case the paper is not then obtained this office should be notified, so that the missing paper may be supplied.*

When a Subscriber changes his address *he should notify this office at once, so that the paper may be sent to the proper destination.*

IMPORTANT.

The following extract is taken from Order No. 907 of the Postmaster-General, containing amendments to the Postal Laws and Regulations applicable to second-class matter, effective Jan. 1, 1908.

"Unless subscriptions are expressly renewed after the term for which they are paid, within the following periods:

Dailies, within three months;
Tri-weeklies, within six months;
Semi-weeklies, within nine months;
Weeklies, within one year;
Semi-monthlies, within three months;
☞ *Monthlies, within four months;*
Bi-monthlies, within six months;
Quarterlies, within six months,

they shall not be counted in the legitimate list of subscribers, and copies mailed on account thereof shall not be accepted for mailing at the second-class postage rate of one cent a pound, but may be mailed at the transient second-class postage rate of one cent for each four ounces or fraction thereof, prepaid by stamps affixed. The right of a publisher to extend credit for subscription to his publication is not denied or questioned, but his compliance or non-compliance, with this regulation will be taken into consideration in determining whether the publication is entitled to transmission at the second-class postage rates."

Will you not co-operate by remitting at the expiration of your subscription?

STEEL PASSENGER EQUIPMENT.*

By Charles E. Barba and Marvin Singer.

THE UNDERFRAME.—PART III. (FORM I. CONTINUED.)

Synopsis.

THE CENTER SILLS AS A COLUMN.

Referring to the previous article.—In the last sub-heading the center sills were briefly dwelt upon in their capacity to act as a column to resist service shocks due to buffing. Therein was noted the fact that to solve the problem, considering the column as one with free ends and a length equal to the total length of the sills over the platforms, was foreign to the design and would introduce fictitious stresses running far above the ultimate strength of structural steel as given in the manufacturers' specifications. The conclusion, based upon this fact, was drawn that the design should be so worked out that short portions of the beams included between the transverse supports would partake of the nature of short compression pieces with fixed ends. The ends being fixed by the construction in the locality of such support would reduce the normal deflection, and hence the bending moment and stress at the center of each sub-span.

Rankine's formula:

$$S = \frac{P}{A}\left[1 + \theta\frac{l^2}{r^2}\right] \quad \ldots\ldots\ldots\ldots\ldots \quad 1$$

was specified as being the best to apply to this case where

P = end shock (static).
A = sectional area.
l = span length in inches.
r = radius of gyration.
θ = constant depending upon the material and end construction, tables for which are given in Merriman's "Mechanics of Materials."

This formula shows that

$$S_1 = \frac{P}{A}$$

is a direct stress due to the buffing force being equally distributed over the area and that accompanying it is a stress

$$S_2 = \frac{P}{A}\,\theta\,\frac{l^2}{r^2}$$

due to the struts deflecting throughout the span and introducing flexural strains which reach the above value at the middle ordinate of the span. The proposition was advanced that this latter stress should be used as a measure of a uniform load which would produce a bending action of approximately the same amount throughout the beam. This uniform loading was noted to be considered as acting at right angles to the uniform loading imposed upon the same beams by the central floor and capacity loading. Quoting the final sentence: "This condition holds when the transverse supports are firm in a combination of either tension or compression and flexural stresses and the center sills have their greatest least radius of gyration about a vertical axis, as is true in this case."

To make this condition strictly true there should be added to the above necessities, that the connections at the platform ends should be such that any load, coming upon the buffers or end casting, would be taken concentrically by the center sill beams. This is a feature which must not be overlooked under penalty of having destructive secondary stresses brought into action by the bending moment due to the eccentric action of the end shock about the vertical neutral axis of these beams.

The preliminary study for necessary sections may be hasty and many refinements may be avoided, but a final investigation should be made of each design using net areas and whatever expedients are necessary to secure a just appreciation of what the frame will measure up to when put to the test.

Though this article pays most attention to the idea that the center sills as struts will deflect in a horizontal transverse plane, there is a possibility that the car may so alter the conditions that it will be the vertical longitudinal plane instead. The final investigation then should cover the latter assumption and the fitness of the calculated beams should be examined as if the end shock was acting about the horizontal neutral axis of these sills and as a consequence with a tendency to augment the bending due to the vertical lading. This is a natural consequence of concentric end loads acting upon a side loaded girder—that they tend to increase the present deflection. The conditions surrounding this type of underframe design are peculiar, in that the sills are so much weaker in the horizontal plane than the vertical that when the supports are spaced close enough to fulfil the short strut conditions demanded of the center sills they will still be found to be weaker in this plane even after the effect of the lading in the vertical plane has been imposed. There are certain constructive features, such as weights of lading, size of beams and disposition of transverse supports, which introduce disturbing elements and no hard and fast rule can be laid down concerning the line of weakness. Both planes must accordingly be solved.

Eccentric End Loads.—The fact that the end load hardly ever impinges concentric with the vertical, due to the end design, will not be dealt with at any length here, as this same question of eccentric loading has been discussed in a previous section (January, 1908, p. 13). In that case the load was eccentric in the horizontal plane, but the principle remains the same, except that in this case the forces and leverages are at quadrature to what they were in that one. This principle involves the addition of the eccentricity of load application to the maximum deflection of each span for total leverage of the end load to secure the maximum bending moment. In this case the general equation of the arm would be the same

$$e + \int_{x=0}^{x=\frac{l}{2}} Y dx$$

where e represents this eccentricity in inches and Y represents the equation of the elastic curve. This equation must here be made

to suit the conditions of a continuous column of which each span is similar to a strut with fixed ends. Having secured the deflection from the integration of the curve, the procedure is similar to what follows after the deflection for the concentric loading has been determined.

Concentric Loading.—If formula (1) be transposed into the form

$$P = \frac{SA}{1 + \theta \frac{l^2}{r^2}}$$

it is evident that the maximum end load, which the center sill column is capable of sustaining without exceeding a specified fiber stress, is decreased from the load, which a simple compression piece will sustain, by just such an amount as the quotient obtained from dividing the product of the stress into the area (SA) by $1 + \theta \frac{l^2}{r^2}$ is decreased by increasing unity by $\theta \frac{l^2}{r^2}$. Unity in the denominator thus denotes the divisor which obtains for the simple compressive stress uniformly distributed over the sectional area and $\theta \frac{l^2}{r^2}$ represents the reduction factor introducing the effects of flexural bending. With a given material and end arrangement, the slenderness ratio $\frac{l}{r}$ governs the destructive action of these concentric end loads, apart from the direct compressive stresses. To increase the value of the static equivalent of the permissible end shock, or inversely to decrease the stress occasioned by any assumed maximum load, it is therefore advisable to design the strut with this quantity as fractional as con-constructive limitations will permit. Decreasing the value of l or increasing the radius of gyration in the plane of distortion will accomplish the result sought. This of course assumes that these quantities are varied without the change in design affecting the value of θ. The value of l is generally determined from conditions obtaining in the superstructure. The arrangement of windows desired, limits the post spacing for the sides. These posts are the vertical stiffeners for the load sustaining girder and the transverse supports should impose their load upon the side sills in the region of the vertical posts, if the minimum stresses are to be had in the web and top and bottom members of the vertical girder. The limitations governing the available variation in l are apparent from the above considerations of minimum stress. The value of r, however, submits to the easiest variation for the securing for any appreciable reduction of stress. This should be as large as weight limitations will allow.

It is not necessary that structural shapes be used for the sills, nor is it required that the shapes be used as found in the cars now running designed after this form of framing. It is customary to construct these underframes with the center girder composed of two separate sills of commercial I or channel section. No cover plates are used and the only effective bond existing between the structural girders or columns is at the regions of transverse supports and this is at fault when but the bottom flanges are fastened to these supports. The resistance offered to bending in a horizontal transverse plane is quite low in this character of design, as the radius of gyration can be considered but double that calculated for a single shape. Latticing the two sills is of doubtful value as regards the effects of this bending. Cover plates are the only efficacious method to take up these bending moments. The fact that the radius of gyration is independent of the spread of the separate sills simply makes the problem one of dividing the total shock evenly between the two columns and designing each beam for its proportion of the load. The bad feature is the great proportionate difference in values of r for the two perpendicular axes. There should be a preponderance in the vertical plane, as the static loading is ever imposed in this direction. An investigation of tables showing varying weights of standard sections produces the conclusion that the I section offers the best advantage for use in this connection, but even here the preponderance is too large, for instance, the heaviest 6-inch I section gives a ratio of radii of gyration as 1 is to 3.4 for the horizontal to vertical planes.

In studying what effects the disposition of the separate beams, with respect to the longitudinal center line of the car, would have upon their resisting qualities we have arrived at conclusions at variance with the opinion of some car designers, but unfortunately have not had oportunity to develop them into an actual construction to note their value. It has been stated that the placing of the sills with respect to one another, that is, the distance apart will not affect their value as resisting bodies for any end shock coming upon them. Looked at in the light of a column this conclusion seems true, for the direct stress is $\frac{P}{A}$ and the flexural, $\frac{P}{A} \theta \frac{l^2}{r^2}$, as noted before. This result changes when the expedient used later on is adopted and the bending is assumed to have been occasioned by a side load producing the same deflection. This expedient rests on a sound theoretical basis. In this case the center sills become central resisting bodies of a bottom girder or truss, and the more remote or the nearer they are to the center line of the car, just in such degree is their effect upon the resistance to this imposed side load changed. This is clearly seen in the first term of the moment formula for the plate girder solved later on. This whole analysis rests upon the basis that the center sills must bend together and in the same direction which they must do to avail themselves of the efficiency of the deep floor girder for strength in this plane. Additional ties should therefore be spaced between the two beams at points between the transverse supports. The manner of load transference through the trussed and plate floor girder is discussed separately under each type of girder. There is a construction, however, which this same question of spacing of sills and the probability of wider spacing tending to the imposition of eccentric end shocks, has brought to our attention. That is, the possible method of making the center sills independently and separately assume their share of the load and in bending so construct them that their tendencies toward bending and deflection oppose each other and neutralize. Thus there would be no load in the transverse horizontal plane to come upon the floor girder and the side sill angle could not be loaded with this twisting force upon it. The transverse supports could here be designed but for vertical load carrying.

This idea would require additional weight in the center of the car, but just how much we are not prepared to state, as the idea has not been developed by us to reach any definite result. From what has been done we feel safe in predicting that it will show economies, and if so we shall present at a later date the lightest design of this type of underframe which can be built to stand up under the service. If this idea has been used in the design of any cars thus far built it has not come to our notice, and the following mathematics and presentation will be made to cover designs which have been built or are now being worked out.

The concentric column load deflects the sills and produces a bending moment which is theoretically indeterminate from any column formula. This follows from the fact that in developing the relation between stress and imposed load by means of the elastic curve of such bending, the deflection is found on both sides of the general equation after the integration has been twice performed and hence the deflection cancels out and the arm of action of the imposed end load cannot be determined. This moment would be $P\triangle$ where $\triangle$ is the indeterminate deflection.

However, the stress occasioned by this moment is given and found to be

$$S = \frac{P}{A} \theta \frac{l^2}{r^2}$$

This can be used as a measure of a uniformly distributed side load producing the same stress.

From the construction necessary to make the sills sustain the assumed end shock—that the connection at the cross bearers must

be rigid so that the sections of the sills between transverses may be solved as short struts—it is evident that the strut is in the condition of fixed ends and that the side load distributed over the sills would in reality make of them a continuous beam in the horizontal plane.

The equation of the stress $S = \frac{P}{A} \theta \frac{l^2}{r^2}$ to the stress $Mx \frac{c}{I}$ according to this assumption, where Mx is the moment at the center of the span of a continuous beam uniformly loaded, is complicated since, as was previously derived (March, 1908, p. 84)

$$Mx = \frac{M_n + M_{n+1}}{2}$$

and the general equation for relation between moments, spans and loads of such a beam when evaluated for Mn gives

$$M_n = \frac{\frac{w_n}{4} l^3_n + \frac{w_{n+1}}{4} l^3_{n+1} - 2\, M_{n+1}\, (l_n + l_{n+1}) - M_{n+2}\, l_{n+2}}{l_n}$$

and M_{n+1} is of the same general form. This procedure is prohibitive on account of its length and opportunity for error. To secure a solution and derive the value of w sought, it would be necessary to evaluate all the forms down to the center of the car and then eliminate backwards because the values of the unknown moments are met with throughout the series of equations. The equation of the formulæ showing the relative strength and stiffness of beams, referred to in the December issue, p. 457, but not worked out, will not avail any more than the value of the stress alone. Thus

$$P = \frac{EI\triangle}{L^3} k_1 \text{ for stiffness}$$

$$\text{and } P = \frac{SI}{Lc} k_2 \text{ for strength}$$

when equated give

$$\triangle = \frac{k_1\, SL^2}{k_2\, c}$$

The value of the deflection is thus determined, but it is in terms of the stress which leads at once to the same result as the procedure just dismissed.

Since the value of uniform load w is desired it is evident that $\triangle$ should be expressed in terms of that quantity. Each span of a continuous beam is the same as a beam with overhanging ends which in turn reduces to that of a beam with fixed ends when the overhang is the same at each end. This is the condition which obtains at the central region of the car for several spans and the use of the value of the deflection of such a beam will be very close to accuracy.

In this case

$$\triangle = \frac{1}{384} \frac{wl^4}{EI}$$

The bending moment at the middle of the span with an end load P acting with this lever arm is $P\triangle$ and the corresponding stress is

$$P\triangle\frac{c}{I}$$

where I is the moment of inertia and c is the distance to the extreme fiber of the cross section.

This is the same stress as was formerly noted to be

$$\frac{P}{A} \theta \frac{l^2}{r^2}$$

When these two values of stress are equated and the values of

$$\triangle = \frac{1}{384} \frac{wl^4}{EI} \text{ and } A = \frac{I}{r^2}$$

are substituted the value of w is found to be

$$w = \frac{384\, \theta\, EI}{cl^2}$$

When the data in the previous article was assumed, it was the intention to present a complete mathematical calculation for the special case paralleling the theoretical exposition. Not having the necessary available time it has been deemed ample to show how the procedure should be followed to secure proper results. Upon making but a cursory examination of the car in question the value of the uniform side load coming upon the center sills, as a result of their bending, has been found to be almost four times as much as that for the vertical lading. This is under the best possible condition for sills bending in the same direction, worked out under the assumption that the end arrangement is such as to cause the end loads to be taken concentrically by the center sills. Any eccentricity would add to this value of w considerably. The same examination when applied to the total stresses upon the center sills showed that a value of l taken for the maximum span of 70 inches was too long. This would then of necessity have to be shortened, the most feasible method of so doing being to increase the width of the supported length at the transverse supports to at least 8 inches. The reactions on the floor girder will be at least four times as great as those coming upon the side girder from the reactions of the floor load transferred to it by the cross supports.

The assumption of 200,000 pounds end shock for this car carries with it the same recommendations for strength that were formerly advanced for steam service, namely—the total stresses due to the end shock and lading combined shall not total more than the elastic limit strength minus $70 \frac{l}{r}$. The value of this elastic limit should be specified in the specifications. The running of stresses up to the elastic limit applies solely to those portions of framing designed to take end shock. This means the center sills and the floor girder or truss of which the side sills are under a constant strain from being the lower chord of the side girder suporting the vertical load.

For a given value of r a reduction in l brings the allowable stress nearer to the elastic limit and reduces the column formula closer to that for a direct compression piece.

There is a characteristic of struts which can well be dwelt upon at this point, and that is the shifting of the crippling strength with the varying length. Long struts invariably fail when the elastic limit is passed. In the case of short struts experiments indicate that such is not the case. The empirical formulæ developed above seek to take into account this quality of column failure. The end shock, for which a static load equivalent has been assumed, is not a sustained force, as dynamometer experiments indicate. Indeed the peak of force application is so sharp that the stress may run high, but it will not come and go faster than the resisting stress can follow and oppose it. The end shock is thus a sudden load.

No recommendations for the tensile strength are required for the reason that, for the service to which the usefulness of this type of car has been limited, these strains are small compared to the buffing loads and can be made to come concentric with the neutral axis of the center sills. Provisions for maximum buffing strains insure ample reliability for the shocks arising from whatever pulling strains arise in service even with the deep center plate fastened to the car body.

The center sills thus fulfil the conditions of a continuous beam in both the vertical and horizontal planes, and have besides the combination flexural stress, a direct stress due to the static end load. The general moment formulæ solved for the vertical plane hold true for the horizontal, if the values of w be used as found in the above calculations. In other words, having solved for the values of vertical moments and tabulated them, the corresponding horizontal moments may be written down as that proportion of the vertical moment as the uniform side load is of the uniform vertical load.

In order to meet the condition that the struts must fail in their main members, the connections between the transverse supports must not only be rigid as before noted, but must take care of the reactions due to the lading in the two perpendicular planes. These reactions are to be found in various ways from the data already worked out. The value of the reaction is the same as the value of the adjacent shear which is of great assistance when

plate girders are used, as the shears are needed to examine the girder. They may also be solved from the moment formulæ—that is, by taking moments about the various points of support in succession.

$$\text{Thus } R_1 l_1 - \frac{w_1 l_1^2}{2} = M_2$$

which may be solved for R_1.

Likewise

$$R_1 (l_1 + l_2) + R_2 l_2 - w_1 l_1 \left(\frac{l_1}{2} + l_2\right) - \frac{w_2 l_2^2}{2} = M_3$$

from which R_2 may be found after R_1 is known.

This procedure when continued up to the center of the car will give all the reactions sought. No matter which way they are secured the total values should add up to the same amount as the total imposed load.

When these vertical reactions are found a procedure similar to the one used for finding the horizontal moments will give the horizontal reactions.

Were it not necessary that these reactions be used to secure the values of the strains imposed upon the floor and side girders, the investigation could cease after the longest span with the most destructive vertical moment had been investigated.

TRANSVERSE SUPPORTS.

After these reactions are found and tabulated the data is given upon which the design of the transverse supports is based. These supports are then first—a simple beam with a central concentrated load, and second—a strut with an end load corresponding to the horizontal reaction; the horizontal reaction generally being the greater.

Care must be taken in the design to prevent this horizontal component of the total load from acting eccentrically to the center and side sills. The nature of these secondary stresses produce a number of evil effects. If the center sills are fastened to the supports but at the lower flanges there is a twisting moment set up in these sills which produces an unnecessary torsional stress within them. If the transverse supports be loaded eccentrically there is a bending action set up in them which would help to increase their existing bending moment and thus transfer a greater reaction to the side girder in a vertical plane, to be added to the weights of the superstructure.

To provide for construction which makes these secondary stresses possible requires additional weight and should be avoided as far as possible. The stiffness of the transverse supports in the vertical plane is of paramount importance. They must not be weak so that the center sills are allowed to sag under their load, else the condition would obtain of having the end shock acting upon the center sills with a vertical lever arm which will increase the stress at a very rapid rate since the end load is measured in 100 thousands of pounds at a maximum and not hundreds, as is the vertical load. The illustration* is not intended to be a mechanical working out of these ideas; this will come when the design previously referred to appears.

The transverse support must then be secured against its tendency to translation in the horizontal plane as well as the vertical. Fixing its ends to serve this need makes of it the strut spoken about above. These points of support are to be found only in the side sill angles and diagonal bracing or in a floor plate together with the side sills. This introduces a feature of design for cars with weak center sills to absorb end shock that is acting in most cars, though not always at its best, because this function of the transverse bracing has frequently been overlooked and fullest advantage not taken of its possibilities.

The value of the floor girder in a transverse horizontal plane is also worth studying.

FLOOR GIRDER.

This resisting framing element is a vertically shallow plate or trussed girder, the nature of which makes it not capable of sustaining a great end load without undue deflection or bending. Its resistance is not due to any large degree of rigidity in its longitudinal direction, but from the fact that it takes the reacting resultant of bending strains from the center sills in the transverse plane. This floor girder is called upon to perform the function outlined whenever the center sills are weakest transversely. When, on the other hand, the stress on them from the vertical lading is so severe that the introduction of a buffing shock makes them weakest vertically, then this load is carried through the transverse supports to the side girder as a vertical reaction and the side girder assumes to absorb it as a concentrated load coming upon it. In neither case is it proper to assume that the end shock is taken longitudinally by either floor or side girder.

The essential feature of this floor girder is that the center sills and side sills must preserve their relative alignment at the points of support for all loads coming within the assumed maximum. This may be accomplished in various ways.

Trussed Floor Girder.—The use of diagonal braces so connected that they form a trussed girder with the two side sills as extreme chords and the center sills as intermediate resisting bodies is a light and rigid construction. It may be braced by diagonals or formed as a Pratt truss with single inclines at the ends and crossed diagonals in the center. The Howe truss is not as well adapted to the purpose. Other considerations being equal the truss must be one in which the members at right angles to the center sills are compression members and the diagonals tension bars, for the least weight.

The same remarks as to the eccentricity of stress transference apply at the points of attachment of these diagonals as to the connections between the supporting struts and the center or side sills. For such secondary stress avoidance the center lines of action of all forces must pass through a common point. The truss arrangement outlined above requires that the separate center sills be connected rigidly to one another at the point of support. Since the transverse supports connect the bottom, this requirement is satisfied if the sills be connected by a plate in this region, the width and depth of which are capable of sustaining half the local reaction, since the other half is taken through the bottom connection.

The calculations for this truss are made as for any framed structure, either algebraically or graphically passing from joint to joint. The data upon which the solution is based consists of the values of the reactions previously found to exist at the points of transverse support. It should be noted that the side sills are strained by the vertical lading and the stresses dare not run up to the elastic limit for this member, since here the question of stiffness as well as strength is of vital importance.

Plate Floor Girder.—The whole floor may be covered by a plate which must be secured to the side sill angles for its extreme members, to the transverse supports as web stiffeners and to the center sill members as central resisting bodies. This type of girder will transfer the loads to the side sills quite differently than the trussed girder. In this case the loads are put upon the side sills as uniform and their destructive influence is lessened, though it will be at an increased expenditure and weight. The use of plates not securely fastened to the center and side sills does not alter the condition very much from that of a trussed beam. With a plate girder the transverse struts need not be designed as strong as in the truss for the load carrying in the horizontal plane, since here they simply serve as web stiffeners to prevent the buckling of the plate under the action of the transverse shears. This web plate can be assumed to simply provide for these shears and the four longitudinal chords to provide for the tensile and compressive forces due to the bending moment. This, however, is not quite true, since the web does sustain a portion of the acting moment in just such ratio as the resisting moment of the web is to the total resisting moment of the girder. The method of analysis of this plate girder is based upon the above hypothesis together with the assumption that the vertical shearing strains in the web are of a constant value from the top to the bottom. These shearing stresses are the productive agents of the bending moments and are not quite constant throughout the depth of the web.

(*To be continued.*)

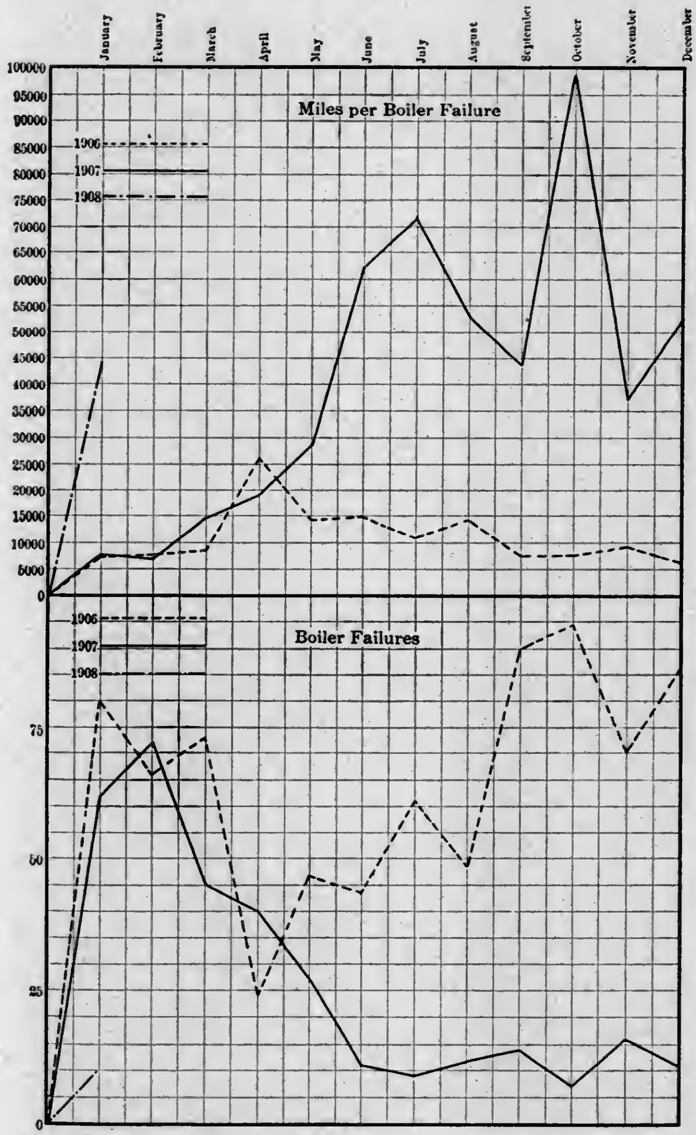
* Will appear next month.

REMARKABLE RESULTS IN LOCOMOTIVE BOILER MAINTENANCE.

The accompanying diagram was furnished by T. A. Foque, mechanical superintendent of the Minneapolis, St. Paul & Sault Sainte Marie Railway, and shows a remarkable improvement which has been made on that road during the past year, as regards locomotive boiler failures. The way in which these results have been accomplished can best be explained by quoting extracts from a letter recently received from Mr. Foque:

"The blue print shows the record of boiler failures during the years 1906 and 1907. The results were obtained largely by the use of a boiler compound.

"Perhaps the most remarkable results have been obtained on that division where we have run a heavy decapod engine for one year at a cost of 26c. for boiler work. Under previous condi-



RECORD OF BOILER FAILURES ON M. ST. P. & S. ST. M. RY.

tions the cost of boiler work would have amounted to several hundred dollars and the fire-box would now be in bad condition. The interior of the boiler, however, may be called perfectly clean and the fire-box and flues show no signs of having been in service.

"In the hard waters the showing has been remarkable, and as we have used the compound since last spring, I believe we can now feel that the results are permanent. The blue print shows what has been accomplished. We have engines in service in fast passenger work which were sent to the shop for fire-boxes nearly a year ago, but instead of shopping them we used the compound and have had no trouble with them since. I am unable to predict when the fire-boxes will have to be taken out and renewed. In our bad water district it was not uncommon for us to shop engines for fire-boxes after they had made from 35,000 to 40,000 miles, and the troubles we experienced with such engines long before they went to the shop resulted in innumerable delays to both passenger and freight trains. We now have such engines which have run a year, or about 60,000 miles, in which there are no signs of weakness, and I do not know how long they will last.

"You should appreciate, too, that on September 14th, 1907, our boilermakers went out on a strike and are out yet, although the strike was officially declared off about a month ago. We were in such shape, however, that we did not see the necessity of taking back the old men.

"I am almost afraid to make public my views regarding the use of this compound. In all my experience I have never seen a compound which, used in a locomotive boiler, would give lasting and beneficial results, and I think that mechanical men throughout the country hold the same opinion regarding such materials as I do. We cannot, however, go back of facts, and with this particular compound my prejudices have certainly been overcome.

"We take the scale out of a boiler without making the boiler leak during the process and then we keep it out. We are not doing one-third of the roundhouse boiler work that we did before we used this material and, unless something unforeseen happens, I cannot see why our back-shop work should not show a similar decrease when we have the engines with weak fire-boxes put in thorough repair.

"This compound has been used on other roads, but I think in no case with the success which has attended its use here. One reason for this undoubtedly is the prejudice which exists against such compounds. It took a lot of hard work to have it used as directed, but when once the system was established and all concerned saw the benefits to be derived, there was no more trouble and I do not believe there is an employee in the mechanical department who does not hold the same opinions regarding the material that I do.

"There is but one way to use it. The suction pipe of one injector must be tapped and fitted with a valve to which a hose is attached, so that the solution may be drawn directly into the boiler through the injector. This is only necessary at terminals, and the engineer need not be concerned about it while on the road.

"I watched our experiments for some months with considerable anxiety, for fear that we might find something which would prohibit its further use, but on some engines we have used it for over a year and cannot discover a single objection to it. This compound is furnished to us by the H. W. Johns-Manville Company."

PERSONALS.

R. F. Kilpatrick, superintendent of motive power of the Delaware, Lackawanna & Western R. R., has resigned.

George S. Hunter has been appointed master mechanic of the Kansas City Southern Ry., at Pittsburg, Kan.

T. F. Carberry has been appointed master mechanic of the Missouri Pacific Ry. at Fort Scott, Kan., to succeed J. J. Reid, transferred.

B. J. Farr has been appointed master mechanic of the Northern Railway of Costa Rica, to succeed T. H. Jordan, who resigned recently.

F. S. Anthony has been appointed master mechanic of the gulf division of the International & Great Northern R. R., at Palestine, Tex.

George A. Hancock, superintendent of motive power of the St. Louis & San Francisco Ry., has been appointed general superintendent of motive power, succeeding Mr. Nettleton, and the office of superintendent of motive power has been abolished.

J. W. Monroe has been appointed division master mechanic of the Chicago, Rock Island & Pacific Ry., with headquarters at Chickasha, Okla.

James Meehan, for many years superintendent of motive power of the Cincinnati Southern Ry., died at his home in Cincinnati, Ohio, on Feb. 28, aged 74 years.

G. T. Hatz, master mechanic of the Chicago & Alton Ry., has resigned to accept the position of superintendent of the Union Pacific shops at Omaha, Neb.

F. T. Hyndman, until recently mechanical superintendent of the New York, New Haven & Hartford Ry., is now representing the Eldo Co., 100 William St., New York City.

Wm. Gell has been appointed master mechanic, in charge of motive power, cars and shops, of the Grand Trunk Pacific Ry., with temporary headquarters at Winnipeg, Man.

E. E. Chrysler, master mechanic of the Chicago, Rock Island & Pacific Ry., at Chickasha, Okla., has resigned, and F. H. Williams, superintendent of motive power, will take charge of the shops.

G. T. Neubert, formerly master mechanic of the Kansas City Belt Ry., has been appointed master mechanic of the Chicago Great Western Ry. at Oelwein, Iowa, to succeed W. P. Chrysler, promoted.

T. S. Lloyd has resigned as general superintendent of motive power for the Chicago, Rock Island & Pacific Ry., and has been appointed superintendent of motive power for the Delaware, Lackawanna & Western R. R.

W. A. Nettleton, general superintendent of motive power of the St. Louis & San Francisco Ry., has been appointed to the same position on the Chicago, Rock Island & Pacific Ry., succeeding Mr. T. S. Lloyd, resigned.

L. R. Pomeroy, who has been for a number of years special representative of the railroad department of the General Electric Co., has gone to the Safety Car Heating & Lighting Co., New York, as assistant to the president.

RAILWAY GENERAL FOREMAN'S ASSOCIATION.

The next annual convention of this association will be held in Chicago, May 25 to 29. The subjects to be discussed are as follows:

The pounding of the left main driving box in preference to the right—What causes the pounding and how can it be stopped? C. H. Voges, N. Y. C., Bellefontaine, O.; E. R. Berry, C., B. & Q., Galesburg, Ill.; W. H. Kidneigh, U. P., Grand Island, Neb.

Modern shop construction—Cross pits or longitudinal, location of wash rooms and lavatories. Best location for each department. Care of shop order material and convenience of storage. L. H. Bryan, D. & I. R., Two Harbors, Minn.; D. E. Barton, Santa Fé, Topeka, Kans.; L. R. Laizure, Erie, Hornell, N. Y.; E. F. Fay, U. P., Denver, Col.

Reporting work vs. engine inspection—Should either be discontinued or are both methods essential? E. B. Moore, U. P., Cheyenne, Wyo.; G. E. B. Warme, 'Frisco, Fayetteville, Ark.; A. E. Thomas, C. G. W., Olewein, Iowa; J. C. Wilkinson, C., R. I. & P., Chawnee, Okla.; E. B. Turner, C. & E. I., Danville, Ill.

The apprentice question—How can we obtain the right kind of material and how can we keep them interested? The benefit of night schools for apprentices maintained at company's expense—Does company obtain sufficient benefit to warrant this expenditure? A. O. Berry, L. S. & M. S, Collinwood, Ohio; H. J. Carrier, Erie, Huntington, Ind.; W. C. Groening, Pere Marquette, Grand Rapids, Mich.; W. G. Larmour, N. & S., Norfolk, Va.; W. Pohlenan, N. Y., O. & W., Middletown, N. Y.

The mileage of a locomotive—Its relation to cost of shop and running repairs—Does it pay to overhaul an engine that will give but 90 days flue or fire-box service? How could this be handled?—Who should determine when to shop an engine, and who should furnish the work report? E. C. Hanse, S. A. L., Savannah, Ga.; G. E. Bronson, C., R. I. & P., Colorado Springs, Col.; George Moore, International, Moncton, N. B.: E. C. Marsh, N. & W., Portsmouth, Ohio.

Why do stay-bolts break more frequently on left side? A. Bradford, Big Four, Urbana, Ill.; H. S. Brickley, E. P. & S. W., Alemogorde, N. Mex.; B. Buzzell, M. P., Poplar Bluff, Mo.; W. H. Clough, Erie, Hammond, Ind.

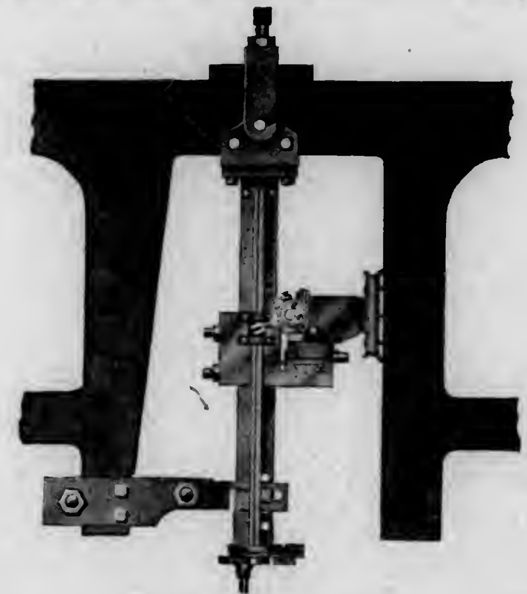
The quick discharging of engines at terminals and how to handle most economically? D. E. Barton, Santa Fé, Topeka, Kans.: G. W. Keller, N. & W., Portsmouth, Ohio; P. W. R. Mark, B. & O., Cleveland, Ohio; William Moore, Erie, Carbondale, Pa.; William Hall, C. & N. W., Escanaba, Mich.

Which is the cheaper to maintain—The piston or slide valve? W. E. Farrell, Big Four, Columbus, Ohio; Ben Beland, 'Frisco, Springfield, Ohio; Joe Claugh, 'Frisco, Oklahoma City, Okla.

LOCOMOTIVE PEDESTAL FACING MACHINE.

The locomotive pedestal facing machine, shown in the illustration, is made by H. B. Underwood & Co., Philadelphia, Pa. Its construction is simple; the method of attaching it to the frame is clearly shown in the photo. A swivel at the top of the vertical bar, which carries the milling head, allows the cutting tool to be used on either pedestal leg. The upright bar or guide can be adjusted to suit the angularity of the pedestal leg. The clamping arrangement at the top is made to suit the widest frame and can be adjusted to suit the narrower ones.

The milling head has a bronze half nut which engages the feed screw which extends alongside the upright bar or guide (at the rear in the view shown in the illustration). The feed is operated by the eccentric on the milling head which drives the square vertical shaft, which in turn drives the feed screw by a ratchet and pawl. The feed may be varied to suit requirements.



PEDESTAL FACING MACHINE.

The milling head may be quickly and accurately adjusted, as it has a motion to and from the leg and crosswise. The universal adjustable clamps at the bottom secure the device rigidly to the frame.

The spindle is threaded to receive the milling cutters; the cutting tools are of high speed steel and are removable for grinding and adjustment. The spindle is driven through gears and a telescopic shaft with universal tumbling joints at each end. If desired a two-cylinder air or steam motor can be furnished for driving the machine.

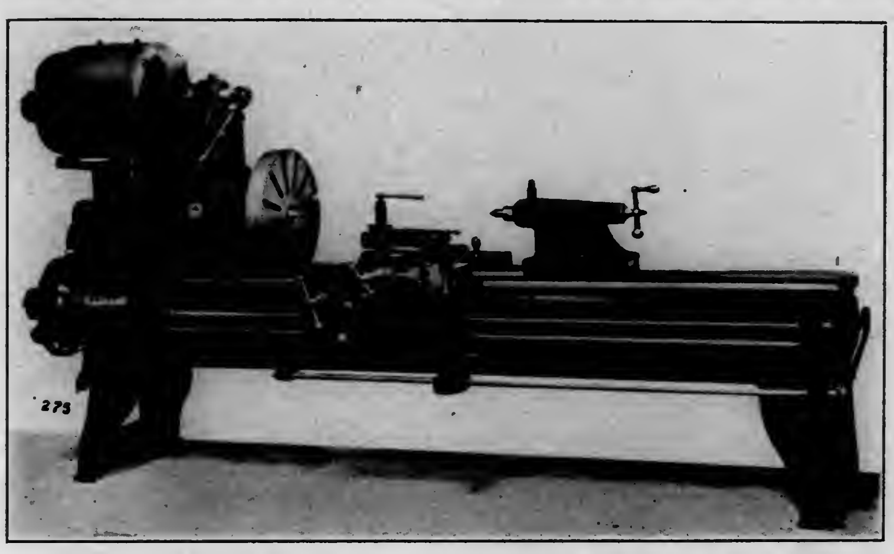


FIG. 1.—APPLICATION OF VARIABLE SPEED MOTOR TO 22-INCH LATHE.

MOTOR DRIVEN ENGINE LATHES.

The machine tool builders have all given more or less attention to the application of the individual motor drive to their tools, especially since the advantages of the individual drive, under certain conditions, have become more and more apparent. The accompanying illustrations show the standard methods of applying individual motors to The R. K. LeBlond Machine Company's (Cincinnati, O.) lathes.

A typical application of a variable speed motor to lathes, up to and including 22 in. swing, is shown in Fig. 1. The headstock has pads cast on the sides, which are planed to receive the motor bracket, or housing. Motors of any make can thus be attached in a neat and substantial manner. A clutch pinion on the motor shaft drives a rawhide gear which runs loose on a 1¾ in. pin, reduced to 1½ in. in diameter where it passes through a bracket cast on the motor housing to which it is held by a nut on the inner side. Only a small portion of this bracket can be seen in the illustration, although the outer end of the pin with an oil hole cap in its center shows clearly.

The rawhide pinion drives a sleeve gear on the spindle which may be locked to the face gear for direct speeds, or can drive the spindle through a double friction back gear. Three mechanical changes are thus available, independent of the motor. The gear covers are arranged to allow easy access to the gears for cleaning and inspecting, and so as not to interfere with the adjustment of the spindle and boxes. For the quick starting and stopping of the lathe, regardless of the motor, a friction clutch has been arranged in the motor pinion and is operated by the long handle at the end of the motor shaft. This device is of considerable advantage when it is necessary to start and stop the machine frequently; without it the lathe stops slowly because of the momentum of the heavy motor armature. The friction clutch is of simple construction, consisting of a bronze ring which is expanded in the periphery of the pinion by a taper wedge or key.

The LeBlond double friction back gear provides, through the lever at the front of the motor bracket, instant speed changes from high to low back gear, without changing a gear and while the tool is running. The back gear is arranged to give a continuous speed range with a 3 to 1 motor; if the motor is operated on the multiple voltage system, the lower voltages are not required, resulting in a more powerful drive, or making possible the use of a smaller motor.

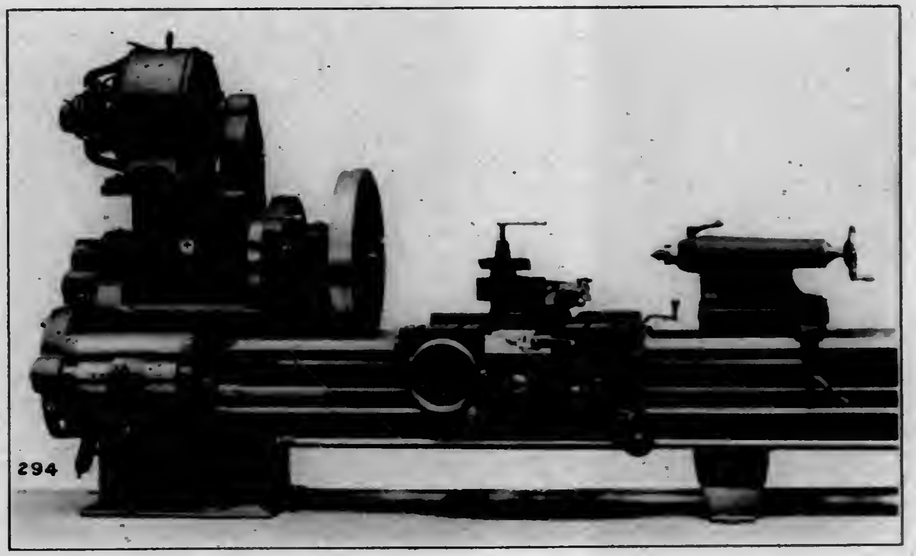


FIG. 2.—APPLICATION OF VARIABLE SPEED MOTOR TO LARGER LATHES.

The motor controller is of the drum type, and is bolted to the back of the lathe bed at the tailstock end. It is operated by a handle on the carriage, through a set of gears, a splined shaft and chain drive, as shown.

On the larger lathes, which require a greater speed range, the motor is applied as shown in Fig. 2. The motor pinion drives a rawhide gear, mounted on a short shaft, with bearings in the gear cover case. The rawhide gear drives a double friction shaft above the spindle and mounted in the motor bracket. This provides four mechanical speed changes. The motor controller is applied as in Fig. 1.

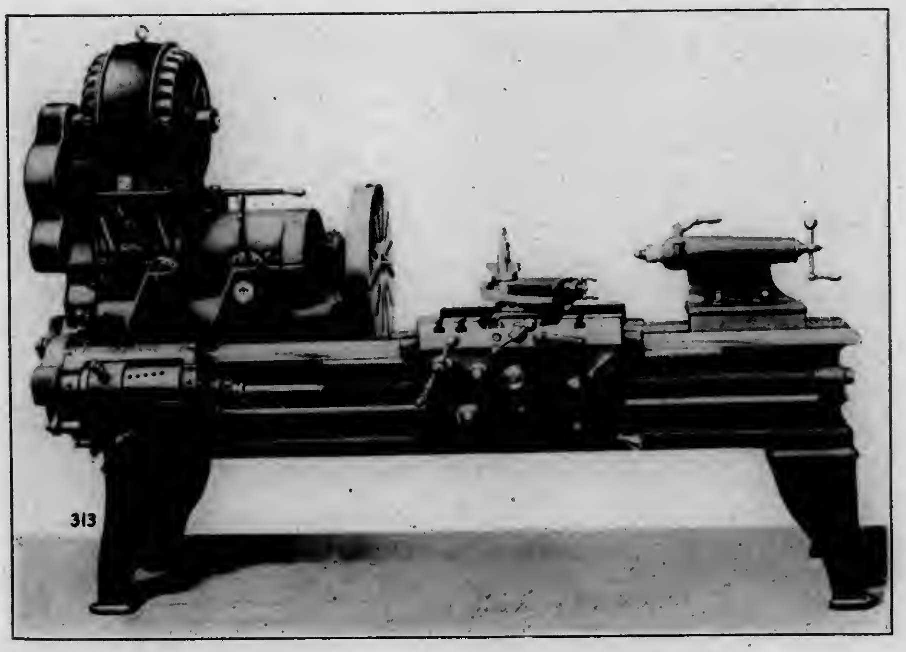


FIG. 3.—APPLICATION OF CONSTANT SPEED MOTOR TO LATHE.

J. W. Monroe has been appointed division master mechanic of the Chicago, Rock Island & Pacific Ry., with headquarters at Chickasha, Okla.

James Meehan, for many years superintendent of motive power of the Cincinnati Southern Ry., died at his home in Cincinnati, Ohio, on Feb. 28, aged 74 years.

G. T. Hatz, master mechanic of the Chicago & Alton Ry., has resigned to accept the position of superintendent of the Union Pacific shops at Omaha, Neb.

E. F. Hyndman, until recently mechanical superintendent of the New York, New Haven & Hartford Ry., is now representing the Eldo Co., 100 William St., New York City.

Wm. Gell has been appointed master mechanic, in charge of motive power, cars and shops, of the Grand Trunk Pacific Ry., with temporary headquarters at Winnipeg, Man.

E. E. Chrysler, master mechanic of the Chicago, Rock Island & Pacific Ry., at Chickasha, Okla., has resigned, and F. H. Williams, superintendent of motive power, will take charge of the shops.

G. F. Neubert, formerly master mechanic of the Kansas City Belt Ry., has been appointed master mechanic of the Chicago Great Western Ry. at Oelwein, Iowa, to succeed W. P. Chrysler, promoted.

T. S. Lloyd has resigned as general superintendent of motive power for the Chicago, Rock Island & Pacific Ry., and has been appointed superintendent of motive power for the Delaware, Lackawanna & Western R. R.

W. A. Nettleton, general superintendent of motive power of the St. Louis & San Francisco Ry., has been appointed to the same position on the Chicago, Rock Island & Pacific Ry., succeeding Mr. T. S. Lloyd, resigned.

L. R. Pomeroy, who has been for a number of years special representative of the railroad department of the General Electric Co., has gone to the Safety Car Heating & Lighting Co., New York, as assistant to the president.

RAILWAY GENERAL FOREMAN'S ASSOCIATION.

The next annual convention of this association will be held in Chicago, May 25 to 29. The subjects to be discussed are as follows:

The pounding of the left main driving box in preference to the right. What causes the pounding and how can it be stopped? C. H. Voges, N. Y. C., Bellefontaine, O.; E. R. Berry, C., B. & Q., Galesburg, Ill.; W. H. Kidneigh, U. P., Grand Island, Neb.

Modern shop construction—Cross pits or longitudinal, location of wash rooms and lavatories. Best location for each department. Care of shop order material and convenience of storage. L. H. Bryan, D. & I. R.; Two Harbors, Minn.; D. E. Barton, Santa Fe, Topeka, Kans.; T. R. Laizure, Erie, Hornell, N. Y.; J. T. Fay, U. P., Denver, Col.

Reporting work vs. engine inspection—Should either be discontinued or are both methods essential? E. B. Moore, U. P., Cheyenne, Wyo.; G. E. B. Warme, 'Frisco, Fayetteville, Ark.; A. J. Thomas, C. G. W., Oelwein, Iowa; J. C. Wilkinson, C., R. I. & P., Chawnee, Okla.; F. B. Turner, C. & E. I., Danville, Ill.

The apprentice question—How can we obtain the right kind of material and how can we keep them interested? The benefit of night schools for apprentices maintained at company's expense—Does company obtain sufficient benefit to warrant this expenditure? A. O. Berry, L. S. & M. S., Collinwood, Ohio; H. J. Carrier, Erie, Huntington, Ind.; W. C. Groening, Pere Marquette, Grand Rapids, Mich.; W. G. Larmour, N. & S., Norfolk, Va.; W. Pohlenan, N. Y., O. & W., Middletown, N. Y.

The mileage of a locomotive—Its relation to cost of shop and running repairs—Does it pay to overhaul an engine that will give but 90 days flue or fire-box service? How could this be handled?—Who should determine when to shop an engine, and who should furnish the work report? E. C. Hanse, S. A. L., Savannah, Ga.; G. E. Bronson, C., R. I. & P., Colorado Springs, Col.; George Moore, International, Moncton, N. B.; E. C. Marsh, N. & W., Portsmouth, Ohio.

Why do stay-bolts break more frequently on left side? A. Bradford, Big Four, Urbana, Ill.; H. S. Brickley, E. P. & S. W., Alamogorde, N. Mex.; B. Buzzell, M. P., Poplar Bluff, Mo.; W. H. Clough, Erie, Hammond, Ind.

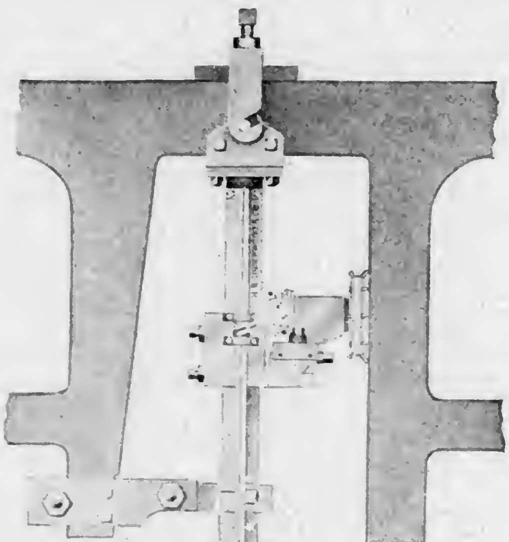
The quick discharging of engines at terminals and how to handle most economically? D. E. Barton, Santa Fé, Topeka, Kans.; G. W. Keller, N. & W., Portsmouth, Ohio; P. W. R. Mark, B. & O., Cleveland, Ohio; William Moore, Erie, Carbondale, Pa.; William Hall, C. & N. W., Escanaba, Mich.

Which is the cheaper to maintain—The piston or slide valve? W. E. Farrell, Big Four, Columbus, Ohio; Ben Beland, 'Frisco, Springfield, Ohio; Joe Claugh, 'Frisco, Oklahoma City, Okla.

LOCOMOTIVE PEDESTAL FACING MACHINE.

The locomotive pedestal facing machine, shown in the illustration, is made by H. B. Underwood & Co., Philadelphia, Pa. Its construction is simple; the method of attaching it to the frame is clearly shown in the photo. A swivel at the top of the vertical bar, which carries the milling head, allows the cutting tool to be used on either pedestal leg. The upright bar or guide can be adjusted to suit the angularity of the pedestal leg. The clamping arrangement at the top is made to suit the widest frame and can be adjusted to suit the narrower ones.

The milling head has a bronze half nut which engages the feed screw which extends alongside the upright bar or guide (at the rear in the view shown in the illustration). The feed is operated by the eccentric on the milling head which drives the square vertical shaft, which in turn drives the feed screw by a ratchet and pawl. The feed may be varied to suit requirements.



PEDESTAL FACING MACHINE.

The milling head may be quickly and accurately adjusted, as it has a motion to and from the leg and crosswise. The universal adjustable clamps at the bottom secure the device rigidly to the frame.

The spindle is threaded to receive the milling cutters; the cutting tools are of high speed steel and are removable for grinding and adjustment. The spindle is driven through gears and a telescopic shaft with universal tumbling joints at each end. If desired a two-cylinder air or steam motor can be furnished for driving the machine.

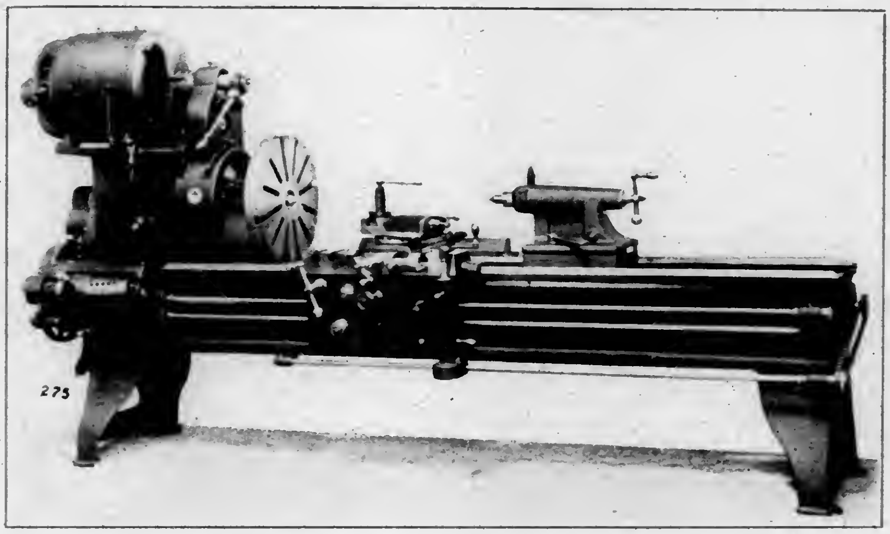


FIG. 1.—APPLICATION OF VARIABLE SPEED MOTOR TO 22-INCH LATHE.

MOTOR DRIVEN ENGINE LATHES.

The machine tool builders have all given more or less attention to the application of the individual motor drive to their tools, especially since the advantages of the individual drive, under certain conditions, have become more and more apparent. The accompanying illustrations show the standard methods of applying individual motors to The R. K. LeBlond Machine Company's (Cincinnati, O.) lathes.

A typical application of a variable speed motor to lathes, up to and including 22 in. swing, is shown in Fig. 1. The headstock has pads cast on the sides, which are planed to receive the motor bracket, or housing. Motors of any make can thus be attached in a neat and substantial manner. A clutch pinion on the motor shaft drives a rawhide gear which runs loose on a $1\frac{3}{4}$ in. pin, reduced to $1\frac{1}{2}$ in. in diameter where it passes through a bracket cast on the motor housing to which it is held by a nut on the inner side. Only a small portion of this bracket can be seen in the illustration, although the outer end of the pin with an oil hole cap in its center shows clearly.

The rawhide pinion drives a sleeve gear on the spindle which may be locked to the face gear for direct speeds, or can drive the spindle through a double friction back gear. Three mechanical changes are thus available, independent of the motor. The gear covers are arranged to allow easy access to the gears for cleaning and inspecting, and so as not to interfere with the adjustment of the spindle and boxes. For the quick starting and stopping of the lathe, regardless of the motor, a friction clutch has been arranged in the motor pinion and is operated by the long handle at the end of the motor shaft. This device is of considerable advantage when it is necessary to start and stop the machine frequently; without it the lathe stops slowly because of the momentum of the heavy motor armature. The friction clutch is of simple construction, consisting of a bronze ring which is expanded in the periphery of the pinion by a taper wedge or key.

The LeBlond double friction back gear provides, through the lever at the front of the motor bracket, instant speed changes from high to low back gear, without changing a gear and while the tool is running. The back gear is arranged to give a continuous speed range with a 3 to 1 motor; if the motor is operated on the multiple voltage system, the lower voltages are not required, resulting in a more powerful drive, or making possible the use of a smaller motor.

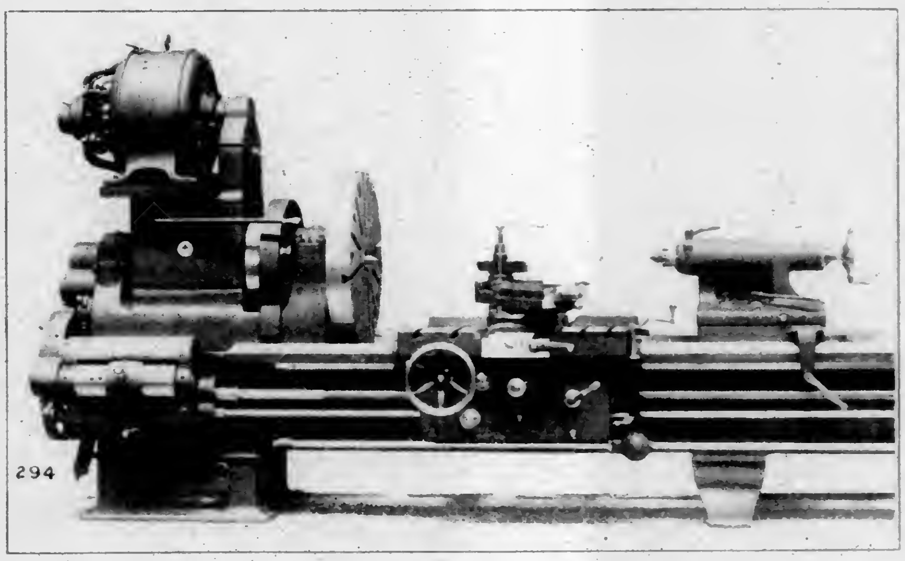


FIG. 2.—APPLICATION OF VARIABLE SPEED MOTOR TO LARGE LATHES.

The motor controller is of the drum type, and is bolted to the back of the lathe bed at the tailstock end. It is operated by a handle on the carriage, through a set of gears, a splined shaft and chain drive, as shown.

On the larger lathes, which require a greater speed range, the motor is applied as shown in Fig. 2. The motor pinion drives a rawhide gear, mounted on a short shaft, with bearings in the gear cover case. The rawhide gear drives a double friction shaft above the spindle and mounted in the motor bracket. This provides four mechanical speed changes. The motor controller is applied as in Fig. 1.

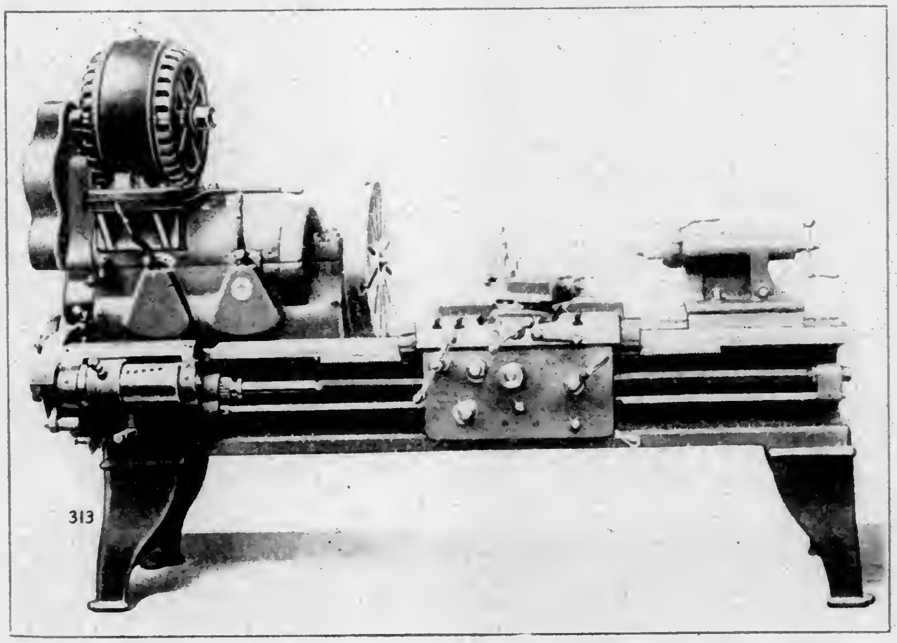


FIG. 3.—APPLICATION OF CONSTANT SPEED MOTOR TO LATHE.

The method of applying a constant speed motor is shown in Fig. 3. The motor is mounted on the headstock and the drive is through a rawhide intermediate gear to the shaft on which are mounted the double friction gears. These frictions are of the standard LeBlond type, are automatic in adjustment and are operated by a lever conveniently located for the operator. This gives two changes of speed, as well as means for quickly starting and stopping the lathe, independent of the motor. The lower shaft has a set of sliding cone gears which multiply the speeds, giving a total of twelve changes. The lathe has no back gears or lock-nut to be engaged, and the entire range of speed may be obtained while it is running. All gears are made of steel; the teeth have beveled edges and are hardened. Those running at a high peripheral speed are engaged with a clutch. The arrangement throughout is very compact and substantial and the gearing is calculated for hard and continuous service.

Another World's Fair.—An international exhibition of industries and labor will be held at Turin, Italy, in 1911. It will celebrate the fiftieth anniversary of the Kingdom of Italy.

High Pressure Steam in Locomotive Service.—The extensive researches of Dr. W. F. M. Goss to determine the value of high steam pressure in locomotive service, which were conducted under the patronage of the Carnegie Institution of Washington, have now been published and can be obtained from that institution at a price of $1.25 per copy.

CATALOGS

IN WRITING FOR THESE PLEASE MENTION THIS JOURNAL.

Screw Cutting Tools and Machinery.—The E. F. Reece Co., Greenfield, Mass., is issuing Catalog No. 6, which includes illustrations, tables of capacities and sizes and a brief description of the very complete line of taps and dies and screw cutting machinery, manufactured by it.

Fibre Conduits.—The Fibre Conduit Co., Orangeburg, N. Y., is issuing a couple of leaflets briefly pointing out the many valuable features of this very light non-conductive insulating type of conduit, which in practical work is found to have many very important advantages.

Instruction Pamphlets—Triple Valves.—The Westinghouse Companies Publishing Department is issuing instruction pamphlets, each of which contains fully illustrated descriptions of the construction and operation of triple valves, there being one on the type L triple valve for steam trains, and one on the type M triple valve which is used for electrically propelled trains in high speed service.

Small Capacity Motors.—The Emerson Electric & Mfg. Co., St. Louis, Mo., is issuing two new bulletins, one showing electric forge blowers, comprising a centrifugal blower with the direct connected motor for either direct or alternating currents, which are equipped with speed regulators and are built in capacities of 150, 300 and 400 cu. ft. of free air per minute. The other bulletin is on the subject of bi-polar ventilated motors of 1/3 and 1/2 h. p. capacity, designed for direct current.

Effect of Brake Beam Hanging Upon Efficiency.—The Westinghouse Air Brake Company is issuing a pamphlet containing a reprint of a most extensive and complete paper on the above subject, presented by Mr. R. A. Parke before the New York Railroad Club on November 18, 1897. The introduction of this pamphlet states that the recommendations of this paper have been followed out in practice with most excellent results and it is considered that the importance of the fundamental principles laid down by the author is sufficient to make it advisable to issue this reprint.

Electrical Machinery.—The General Electric Company is issuing a number of new bulletins among which might be mentioned No. 4548, which shows typical examples of direct and alternating current motors installed on a great variety of lathes, drills, grinders, shears and similar tools, which illustrate the great adaptability of these motors for this class of service. Following a short description of the motors and controllers there are about 15 pages of excellent half-tones. Other bulletins are being sent out on the subjects of fan motors, Tungsten, Tantalum and Edison "Gem" incandescent lamps, as well as flaming arc lamps

Reaction is the title of a new quarterly publication devoted to the science of Aluminothermics, which is being published by The Goldschmidt Thermit Co., 90 West St., New York. This is a technical publication in every sense of the word and gives some very interesting illustrations and most valuable information on aluminothermics. An introductory paragraph states that this book is not being issued to give publicity but simply to keep the engineering world in touch with the best and most up to date practice in welding, which is constantly undergoing improvement. It will be sent free of charge to any one in the U. S., Canada or Mexico.

Buda Water Softeners.—The Buda Foundry & Mfg. Co., Chicago, is issuing Bulletin No. 120 which fully illustrates and describes the Buda intermittent and continuous systems of water softening for use in connection with railroad water stations and power plants. It has been the aim of this company in deciding upon the features of its system to secure simplicity, elimination of moving parts, large capacity and such construction as would make it practically impossible to have any interruption of the operation of the plant, even when handled with very low grade labor. The bulletin fully illustrates and describes the system and gives a number of very interesting illustrations of recently installed plants.

Single Purpose Lathes.—The Fitchburg Machine Works, Fitchburg, Mass., is issuing a very attractively arranged catalog which fully illustrates and describes the valuable features of its new "Lo-swing" lathe. This tool has been designed for the purpose of furnishing a highly specialized machine for a particular class of work. It does only turning on centers, is not arranged for screw cutting or chucking and is limited to a maximum turning diameter of 3½ in. and a working length of 5 ft. The whole machine is designed to do its own particular highly specialized work to the very best advantage and with the greatest rapidity and accuracy. The details of construction and examples of the kind of work the machine is capable of doing are clearly illustrated.

Underframe and Truck Equipment.—A catalog, consisting of a collection of blue prints, giving very well executed perspective views of the different pieces of equipment manufactured by it, is being issued by the Pittsburg Equipment Company, Pittsburg, Pa. The products of this company consist of cast steel parts for car underframes and trucks, comprising many new designs of bolsters, both body and truck, draft sills, end sills, oil boxes, side frames, spring planks, etc. Some very ingenious arrangements are shown for the combination of cast steel body bolsters with structural steel center and side sills, the arrangement being such as to permit a convenient removal of different parts while retaining full strength and using very few separate pieces and bolts or rivets. These bolsters are shown in a number of different designs for various capacity cars and different conditions of service. Arrangements of combined cast steel draft sills and body bolster for any type of draft gear, which are so constructed as to be easily applicable to cars with either wooden or steel sills, and having the construction either integral or separate as desired, form a very interesting part of the catalog. Complete underframes for cars of different capacities employing cast steel bolsters, draft sills and end sill, and structural steel for the remaining parts, are also illustrated. Several designs of cast steel side frames illustrate that the possibilities of introducing new and valuable improvements in this important part have not previously been exhausted. The constructions shown in this catalog are novel and practicable.

NOTES

Dearborn Drug & Chemical Works.—Mr. George R. Carr, vice-president, is on a combination business and pleasure trip to the City of Mexico.

Locomotives Ordered.—The American Locomotive Company has recently received an order through Elberton D. Hitch & Co. for two 2-4-0 type locomotives, with 9 x 16 in. cylinders, for service in Brazil.

Wisconsin Engine Company.—This company announces that it has established a branch office at Atlanta, Ga., under the management of Mr. Julius M. Dashiell, who will be located in the Chandler building.

Bettendorf Axle Company.—This company has received an order for steel under-frames equipped with Bettendorf cast steel trucks and swing motion bolsters for 2,500 stock cars from the Chicago, Milwaukee & St. Paul Railway.

T. H. Symington Company.—Mr. E. H. Symington, who recently returned from an extensive trip in Europe and the far East, has again departed for a foreign tour which will take in South Africa, South America, Australia and New Zealand.

Westinghouse Gas Engines.—The Duquesne Steel Foundry, which operates a large plant in the Pittsburg district, has decided to adopt the gas power system for operating its works formerly driven by steam. The plant will consist of a 400 h. p. Westinghouse three-cylinder gas engine direct connected to a 240 k. w. generator. Natural gas will be used.

A. S. M. E.—The American Society of Mechanical Engineers, with a desire to still further develop their publication, have secured Mr. Lester G. French to direct the editorial department. One of the first improvements to be made will be the establishment of departments in the monthly proceedings. Mr. French, following an extensive experience in practical work, was for nine years editor-in-chief of *Machinery*.

A New Locomotive Bell.—Visitors at the mechanical conventions last year will remember the pleasing tones of a chime of bells which formed part of the exhibit of the National Tube Company. These bells were made of Shelby seamless steel and are formed from a seamless steel tube. They give an excellent tone, are practically nonbreakable and are now being put on the market for use on locomotives. Information concerning them can be obtained from the National Tube Company, Pittsburg, Pa.

BURNING LIGNITE COAL IN LOCOMOTIVES

By O. N. Terry.*

In certain sections of this country the sub-bituminous and lignite coals are practically the only fuels available. The coal mined in the vicinity of Sheridan, Wyoming, is a sub-bituminous coal, but is commonly called lignite,† and where the word lignite is used in this article it should be understood to mean Wyoming or Northern Colorado coal, which in many respects is superior to the average bituminous coal. It is light and clean and almost entirely free from slate or rock. It ignites quickly and burns freely with practically no clinkering, when properly handled. It differs from the bituminous principally in the amount of moisture and ash, the moisture being usually higher than with bituminous coal and the ash lower. When exposed to the sun and air it soon begins to slack and break up into small cubes, which eventually crumble into powder. It is therefore advisable to put it on the locomotive tender without any unnecessary delay after it is mined.

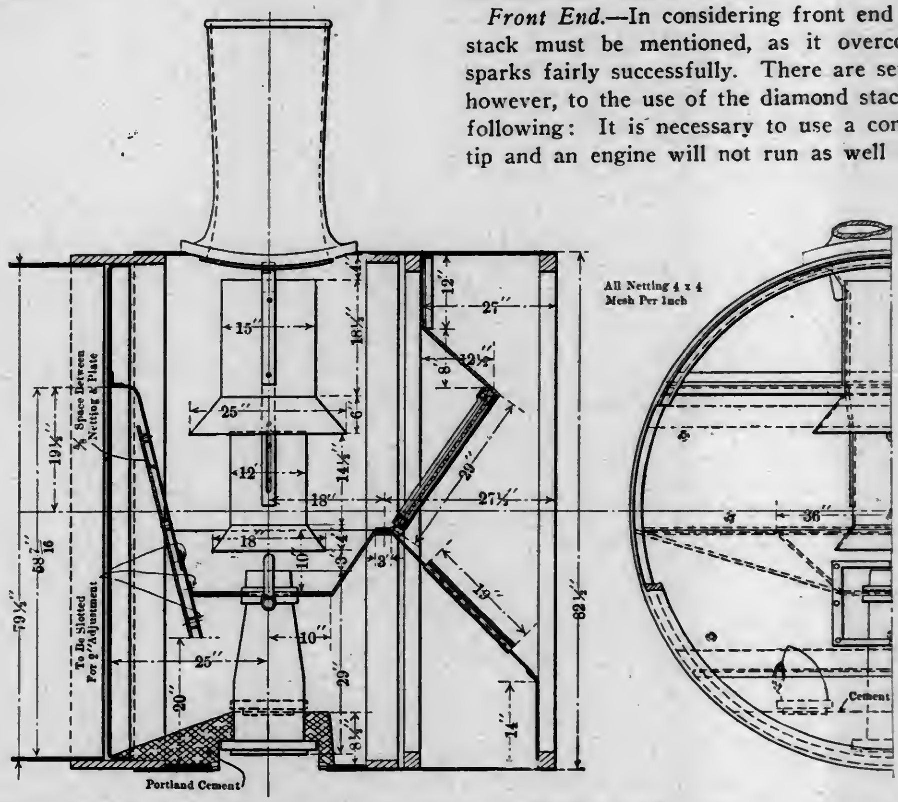


FIG. 2.—FIRST FORM OF FRONT END WITH STRAIGHT STACK USED FOR BURNING LIGNITE ON THE BURLINGTON.

Lignite does not coke when burning, but breaks up into small pieces which are kept moving by the draft when an engine is working hard. As these particles burn, and decrease in size, they eventually reach a point where the draft is strong enough to carry them up, over the arch, through the flues and out of the stack. It is a peculiar property of lignite that these small pieces generally burn until they are entirely consumed, and it is necessary that they be reduced to a very small size before they are permitted to escape. It is therefore apparent that the importance of adequate spark arresting appliances is greater than with bituminous coal. The ash pan should be as tight as possible without any direct openings below the level of the mud ring, that are not covered by small mesh netting. Sufficient air opening may be secured by extending the sides of the ash pan out beyond and slightly above the lower edge of the mud ring, or by leaving space between the ash pan and the mud ring, which is covered with netting.

Grates.—The grate shown in Fig. 1 has proved to be very satisfactory for lignite. It was originally designed with the idea that the increased air opening would reduce the amount of fire lifted from the grates. It is impossible to determine if it has had such an effect, but other advantages, such as simplicity, cheapness, durability, fewer connections, reduction of engine failures, etc., have made it a success.

Brick Arch.—It is generally the practice in burning lignite coal to use a large arch so that the sparks and gases will be consumed before going into the tubes. This should be fitted tightly against the flue sheet and there should be no holes in the arch between the various bricks.

Front End.—In considering front end appliances the diamond stack must be mentioned, as it overcomes the trouble from sparks fairly successfully. There are several serious objections, however, to the use of the diamond stack, among which are the following: It is necessary to use a comparatively small nozzle tip and an engine will not run as well or handle as much tonnage as it otherwise would. The diamond stack is disagreeable to the enginemen on account of fine cinders coming down around and inside the cab. It is expensive to maintain as the cone, netting and top part of the stack cut away rapidly. This of course makes it correspondingly difficult to keep the stack in safe, serviceable condition.

The first form of front end arrangement used with a straight stack on the Burlington road for burning lignite is that shown in Fig. 2. In this arrangement 4 x 4 mesh, No. 12, wire netting was used, coming forward from the diaphragm on the level of the nozzle tip. About half way between the nozzle tip and the front end one layer of netting ran down to a point about even with the lower part of the door opening, and another netting extended up in a zig-zag form to the top of the smoke box. A layer of netting, with an open basket or flare, extended up around the nozzle tip. When both of the front end nettings were clean the majority of the sparks would strike the lower front netting and pass up through the second netting. Generally, however, after running a short distance the upper front netting would stop up with cinders and cinders would accumulate under the lower front netting, frequently causing it to burn out. Upon

* Chief Draftsman, Burlington Lines West of Missouri River.

† Lignite from the Wyoming Coal Mining Company's mines, at Monarch, Wyoming, (Sheridan Co.), on the Burlington & Missouri River Railroad, was tested at the coal testing plant of the United States Geological Survey, at the Louisiana Purchase Exposition, St. Louis. The proximate analysis of this coal was as follows:

Moisture	21.97 per cent.
Volatile matter	35.95 " "
Fixed carbon	37.75 " "
Ash	4.32 " "

The calorific value is about 9,700 B. T. U.

opening the front end door and removing the trap doors in the netting, it would be found that the single layer of netting around the nozzle was perfectly clean. It is, therefore, safe to say that this arrangement was practically a single netting front end of 4 x 4 mesh, No. 12, wire.

With this front end arrangement double petticoat pipes were used and the engines in general gave very good results. The netting, however, from a lignite standpoint, was rather coarse, and as it was difficult to keep the joints between the netting and smoke box in good condition, it was not entirely satisfactory.

The next step was an attempt to use two complete layers of 4 x 4 mesh netting with an inside extension stack built on the lines recommended by the Master Mechanics' Association. One engine was fitted up with two layers of 4 x 4 mesh netting, 5 in.

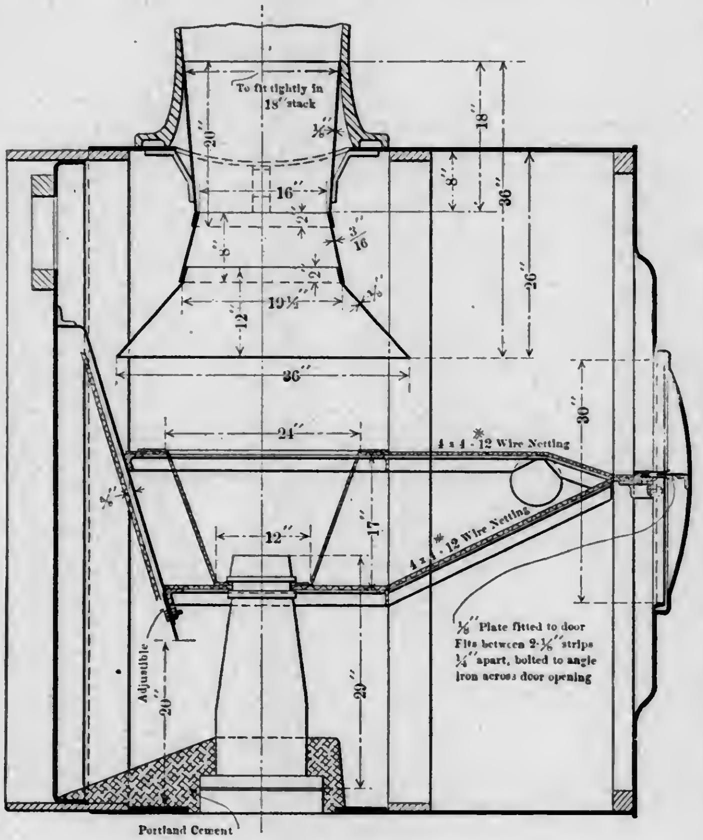


FIG. 3.

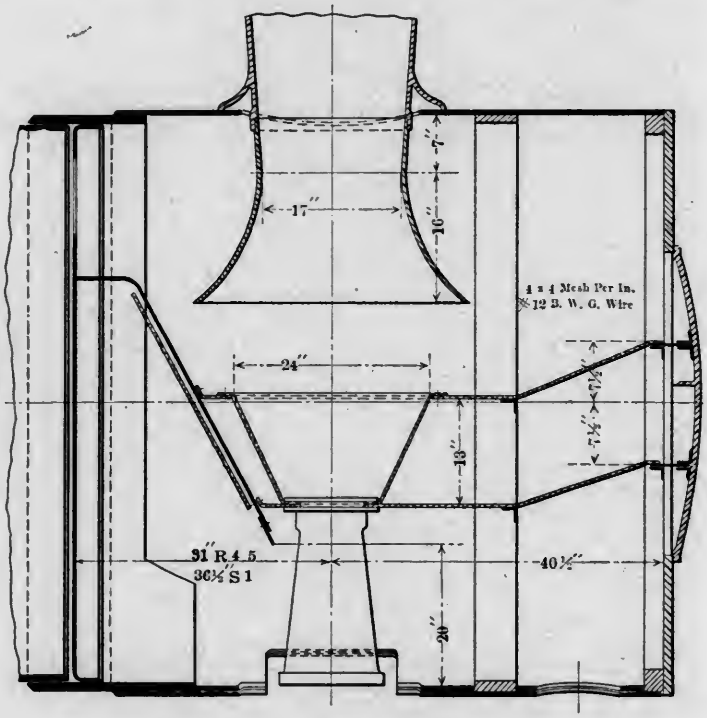


FIG. 4.

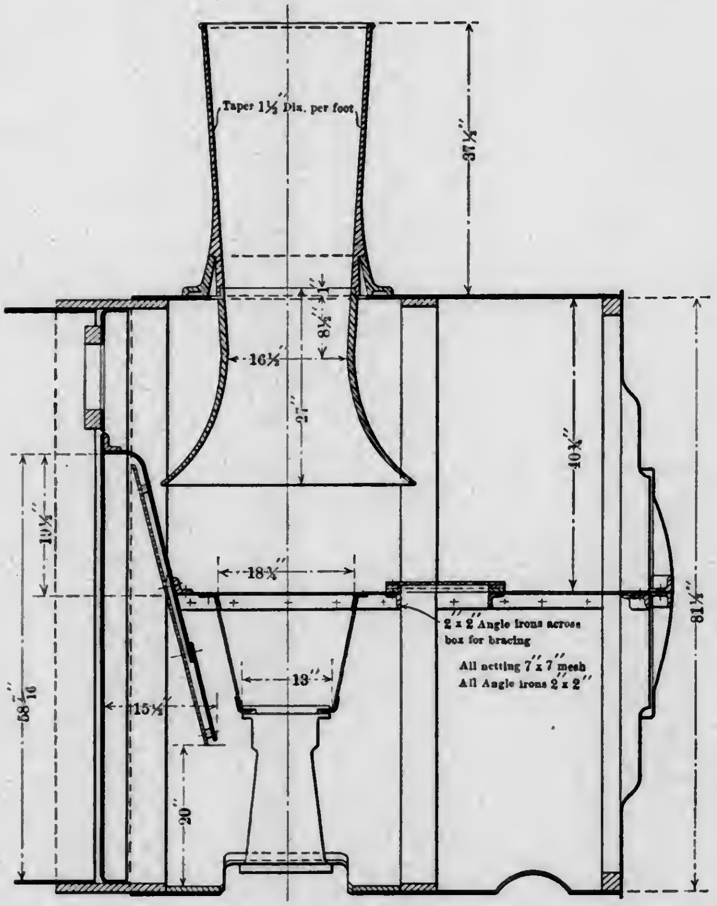
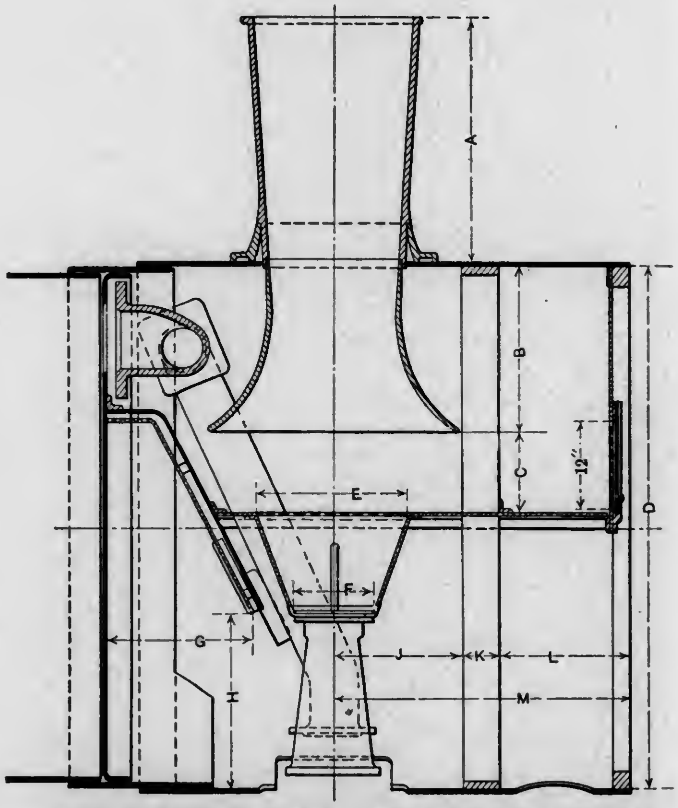


FIG. 5.



Class	A	B	C	D	E	F	G	H	J	K	L	M
R-4, R-5, S-1	45½"	28"	11"	72"	19"	13"	20"	24"	17½"	5"	18"	40½"
D-4-A, D-4-B	37½"	26"	12½"	81½"	20"	13"	15½"	20"	15½"	5"	22 1/16"	45 9/16"

Use 4½" x 4½" Mesh #12 B.W.G. Wire on Diaphagm Plate
" 7" x 7" " #16 " " " . " in Basket & rest of Smoke Box

FIG. 6.

STAGES IN THE DEVELOPMENT OF FRONT ENDS FOR BURNING LIGNITE ON THE BURLINGTON.

apart on a straight incline from the nozzle to the front top part of the smoke box, but the second or top layer of netting caused trouble by stopping up. Later an engine was fitted up in practically the same manner except that perforated plate was used instead of netting. This engine was very successful from a steaming standpoint, but the holes in the perforated plate were too large for lignite coal.

Several engines were fitted up, as shown in Figs. 3 and 4, and gave fairly good results. By keeping the two layers of netting about 12 in. apart the tendency to clog up the top netting was greatly reduced. It was gradually demonstrated that very little was gained by using two complete layers of netting. The Master Mechanics' stack, however, proved to be a decided success. It was noticed that the bottom layer of netting usually remained clean while the top layer clogged up more or less, even in the free steaming engines. It was, therefore, decided to try 4½ x 4½ mesh, No. 12, wire netting for the bottom layer as it was thought that this would reduce the fire throwing and also prevent the upper netting from stopping up. The fire throwing was undoubtedly reduced, but the top layer of netting continued to stop up, even though the individual openings were about 35 per cent. larger than those in the bottom layer. It became apparent that the second or top layer of netting was of very little value and was decidedly objectionable on account of its tendency to clog

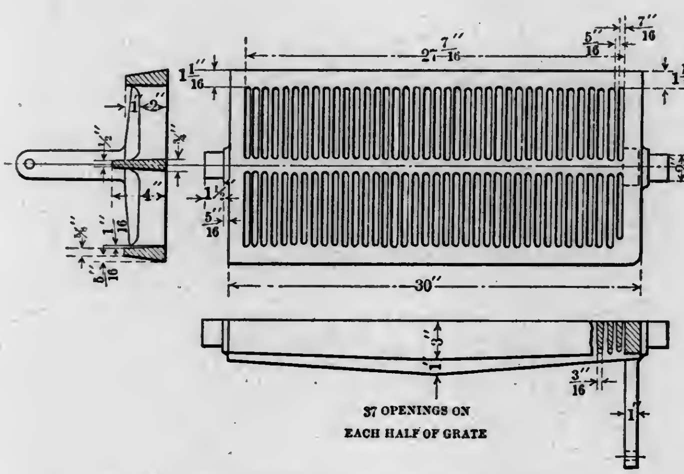


FIG. 1.—GRATES FOR LIGNITE BURNING ENGINES.

up. An engine was accordingly fitted up, as shown in Fig. 5, with 4½ x 4½ mesh, No. 12, wire netting which gave quite favorable results. Another engine was fitted up with 7 x 7 mesh, No. 16, wire netting which gave better results than the 4½ x 4½ mesh, No. 12, wire, both in reducing fire throwing and the tendency to clog up.

Considerable difficulty was experienced in maintaining tight joints between the netting, and front end plate and door, and the design shown in Fig. 7 was made to overcome this trouble. This design with 7 x 7 mesh, No. 16, wire netting gives very good results, but the netting sometimes clogs up with poor, wet slack coal, or when there is a leak of steam or water in the front end, which permits moisture to come in contact with the netting. The same trouble has been experienced with the 4 x 4 mesh, No. 12, wire netting but to a much less extent.

With the Master Mechanics' stack splendid results are obtained in the way of draft. Mechanically it is much superior to any contrivance involving single or double adjustable draft pipes and eliminates engine failures on account of "draft pipes loose," "draft pipe out of line," etc. It has been observed that the netting directly under the flare or bell of the stack remains clean while the netting near the front end door has some tendency to stop up. Horizontal netting does not stop up as readily as does netting which is set on an incline, with this type of stack, and small mesh netting with small wire is better than small mesh netting made of large wire.

In burning lignite exceptional care must be taken in equipping and maintaining the front end appliances, so that there are no holes around the edges where the netting comes against the smoke box, steam pipes, etc. It is practically useless to apply fine mesh netting or spark arrester sheets to a smoke box unless the work is very carefully done. A small crack or space which would not be noticed on a bituminous burner would not be safe on a lignite burning engine. Simplicity, ease of inspection and accessibility for cleaning and repairs are of the greatest importance. A wire brush is about the most efficient device for cleaning the netting and removing cinders which have lodged in the small spaces of the netting. The netting should be inspected and thoroughly cleaned at each end of the division.

To successfully burn lignite large grate area is more essential than with bituminous coal. On engines with small grate area the diamond stack apparently gives the best results, although it is probable that a straight stack design might be worked out. Long tubes and large grate area are undoubtedly important features in lignite burning engines, but there is considerable variation in dimensions of engines which have given good results with this fuel. One class of engines used in passenger service with heavy trains on long divisions under exceptionally severe conditions gave very good results. These were 10 wheel engines, 19 x 26 in. cylinders with 69 in. drivers, grate surface 44 sq. ft., 342—2 in. O.D. tubes, 15 ft. 1 in. long.

Heating surface, fire-box	151.44 sq. ft.
" " tubes	2717.94 sq. ft.
" " total	2869.38 sq. ft.

A consolidation freight engine which gives good service has the following general dimensions:

Cylinders	22″ x 28″
Drivers	57″
Grate surface	54.2 sq. ft.
Tubes	450—2″ O. D. 15 ft. long
Heating surface, fire-box	221.77 sq. ft.
" " tubes	3511.56 sq. ft.
" " total	3733.33 sq. ft.

A Prairie type engine which burns lignite very successfully has tubes 19 ft. long. The general dimensions are as follows:

Cylinders	22″ x 28″
Drivers	69″
Grate surface	54.2 sq. ft.
Tubes	301—2¼″ O. D. 19 ft. long
Heating surface, fire-box	200.0 sq. ft.
" " tubes	3353.4 sq. ft.
" " total	3553.4 sq. ft.

Another consolidation freight engine which does good work with lignite is of the following general description:

Cylinders	22″ x 28″
Drivers	52″
Grate surface	48 sq. ft.
Tubes	375—2″ O. D. 14 ft. 8½ in. long.
Heating surface, fire-box	171.4 sq. ft.
" " tubes	2812.5 sq. ft.
" " total	2983.9 sq. ft.

A Pacific type engine is now being used in passenger service which steams very freely and gives splendid results with lignite coal. This engine has 54.2 sq. ft. of grate area, 303 tubes 2¼ in. O.D., 21 ft. long, and 3932.7 sq. ft. of heating surface, 200 of which are in the firebox; drivers, 74 in. diameter.

From the foregoing descriptions it is apparent that there may be considerable difference in grate area, heating surface and length of tubes in successful lignite burning engines. The general results with 7 x 7 mesh, No. 16, wire netting are very good, especially where the engine is properly handled. There are times, however, when quite a number of small sparks are thrown out of the stack, especially if the fire door is opened when the fire is burned down, but practically all of these are burned out or dead when they strike the ground.

When considering the question of fires caused by lignite burning locomotives, it must be remembered that practically all of the trouble occurs during the dry seasons in a section of the country which has a particularly dry climate, so that even bituminous coal, if it was obtainable, would undoubtedly start more fires than it does in other parts of the country. The present straight stack with 7 x 7 mesh, No. 16, wire netting, may be fairly considered to be equal in overcoming trouble from sparks to any of the diamond stacks that have been successfully used. There is good reason to expect that improvements will be made on present designs of spark arresting appliances which will effectually remove the one objection to the use of lignite coal and establish its position as an excellent fuel for locomotives.

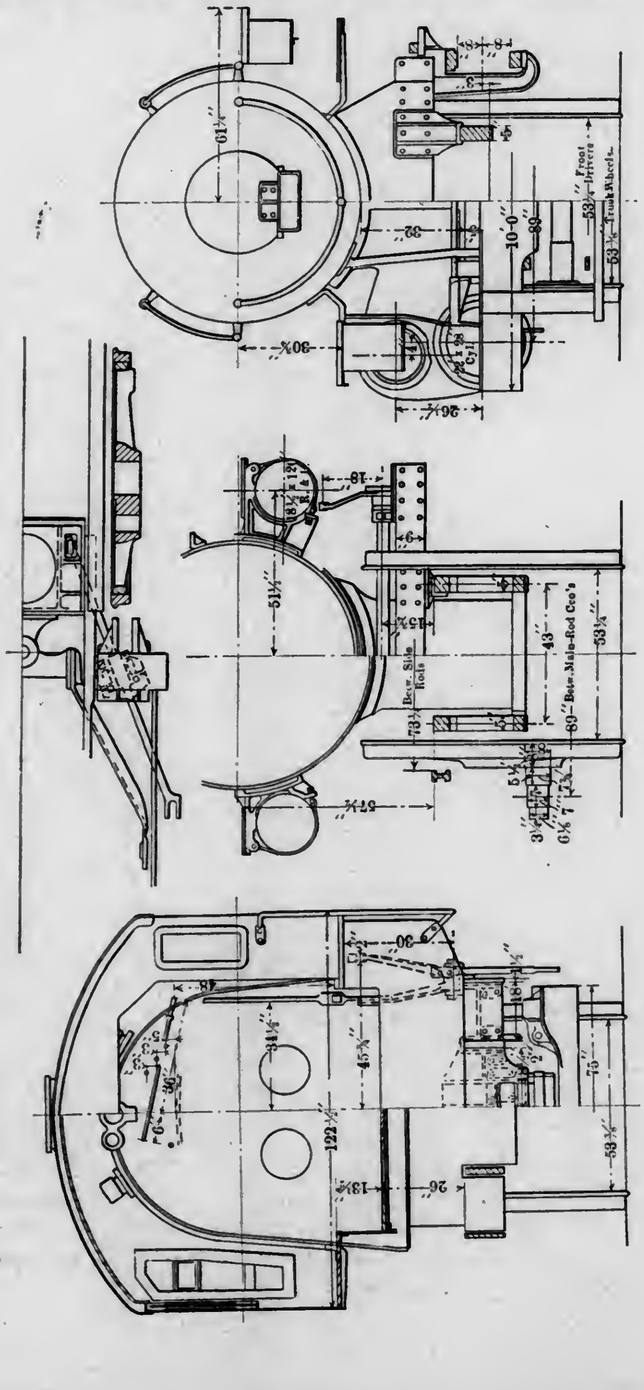
HEAVY PACIFIC TYPE PASSENGER LOCOMOTIVE.

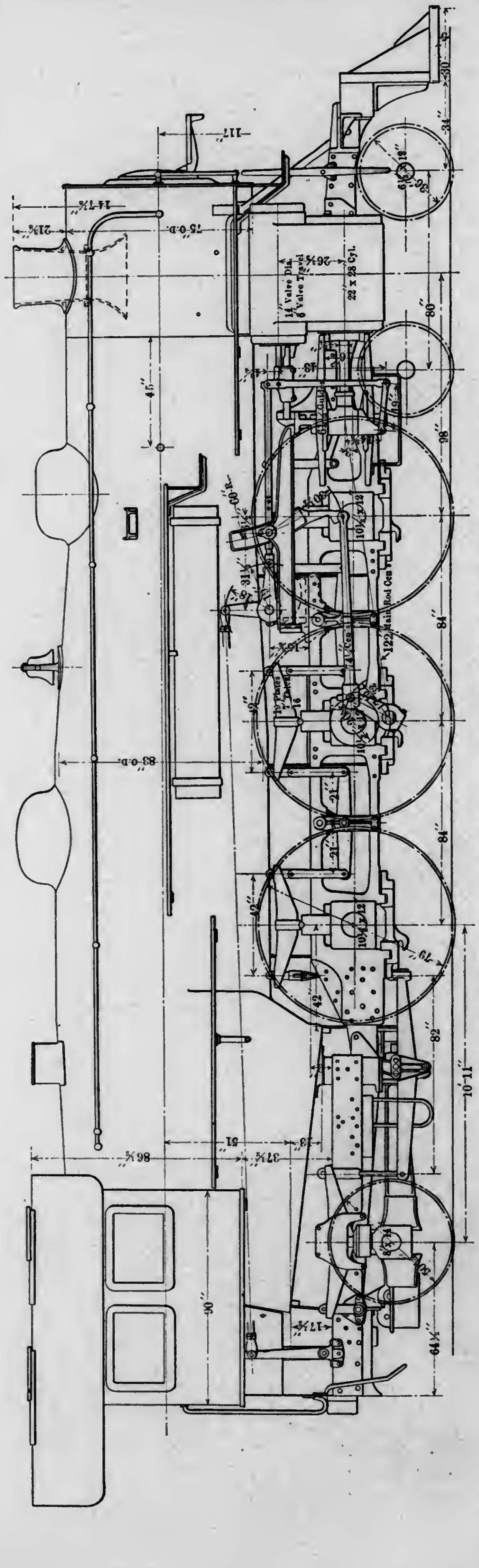
NEW YORK CENTRAL LINES.

There has recently been finished at the Schenectady Works of the American Locomotive Company, 40 Pacific type passenger locomotives for the New York Central & Hudson River Railroad, which are the heaviest ever built for this line, and are practically the heaviest passenger locomotives in the world.

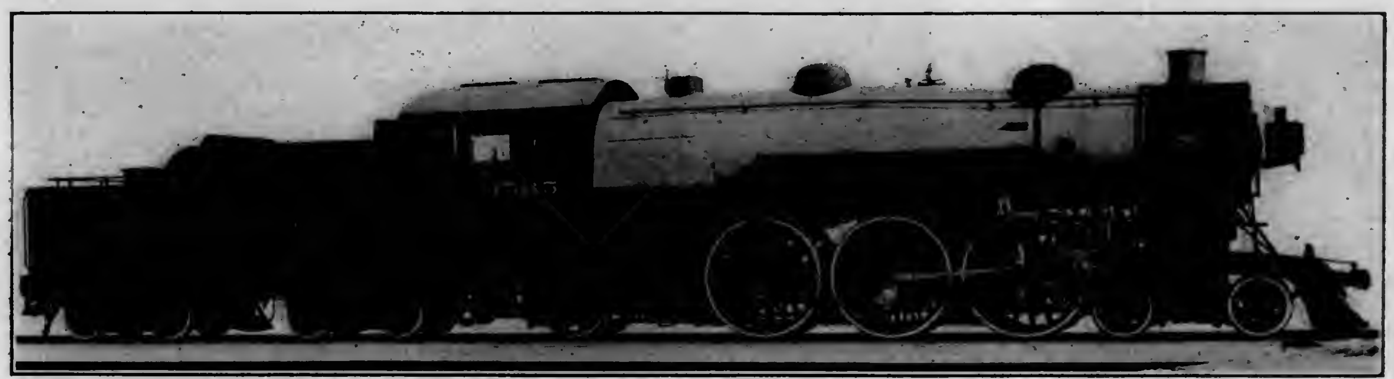
These locomotives are, in all essential details, duplicates of the 25 engines built by the same company last year for the Lake Shore & Michigan Southern Railway, which were illustrated and described on page 365 of the September issue of this journal. Those engines took the place of the Prairie type, as the standard high speed engine on that road, and are now hauling all of the heavier through trains. It is probable that this new class will become the standard type for heavy passenger power on all of the New York Central Lines.

For comparison with previous locomotives of this type, as well as other passenger locomotives, reference should be made to the tables published in connection with a description of a similar locomotive for the Pennsylvania Railroad, page 267 of the July, 1907, issue, the Lake Shore engine above mentioned and the tabular comparison of locomotives published last June. An examination of these comparative tables and of the ratios given in the table below will show that while these locomotives are ex-





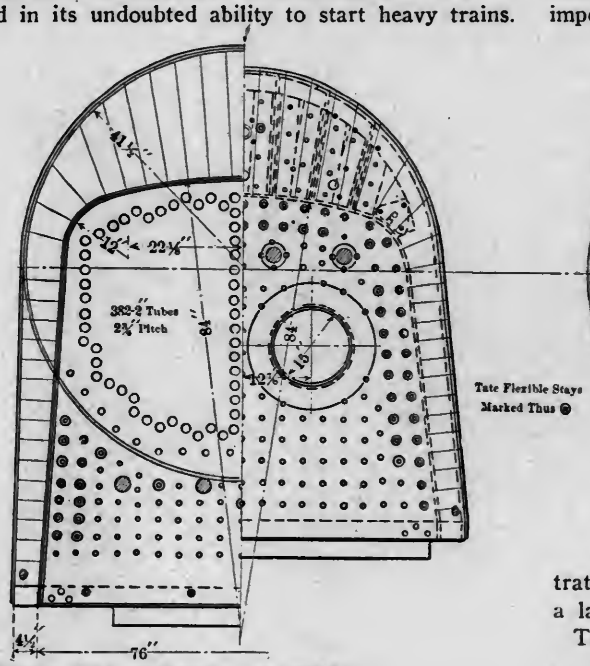
GENERAL ELEVATIONS AND SECTIONS, PACIFIC TYPE LOCOMOTIVE—NEW YORK CENTRAL LINES.



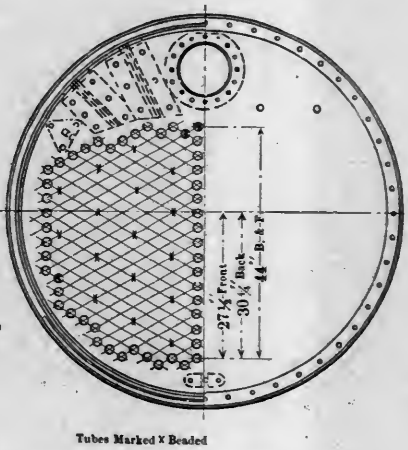
HEAVY PACIFIC TYPE PASSENGER LOCOMOTIVE—NEW YORK CENTRAL LINES.

ceedingly powerful, the power is not clearly indicated by the amount of tractive effort. A theoretical tractive effort of 29,200 lbs. is seemingly small for a locomotive weighing 266,000 lbs., and actually the power of the locomotive lies in its enormous steaming capacity and in its undoubted ability to start heavy trains. The ratio of adhesion of 5.84 shows that there will be no slipping troubles in starting the heavy modern passenger train of 10 to 15 cars even at stations located on curves. The B. D. ratio of 550 is considerably below the average figure for Pacific type locomotives, but is one which has been approached in all of the later designs of passenger locomotives on the New York Central Lines and shows that they certainly will not be deficient in steaming capacity.

The general construction is shown in the illustrations, as is also the general design of the very large boilers. The Walschaert valve gear is, of course, used, the design being very similar to that applied to the Lake Shore engines, the only noticeable difference being in connecting the reach rod to an upwardly extending arm on the reverse shaft, thus making the eccentric crank pin follow the main pin instead of leading it. The other important features of construction are clearly shown in the illustrations. Some of the more interesting details will be shown in a later issue.



SECTION AND ELEVATION OF FIREBOX.



SECTION THROUGH FRONT END.

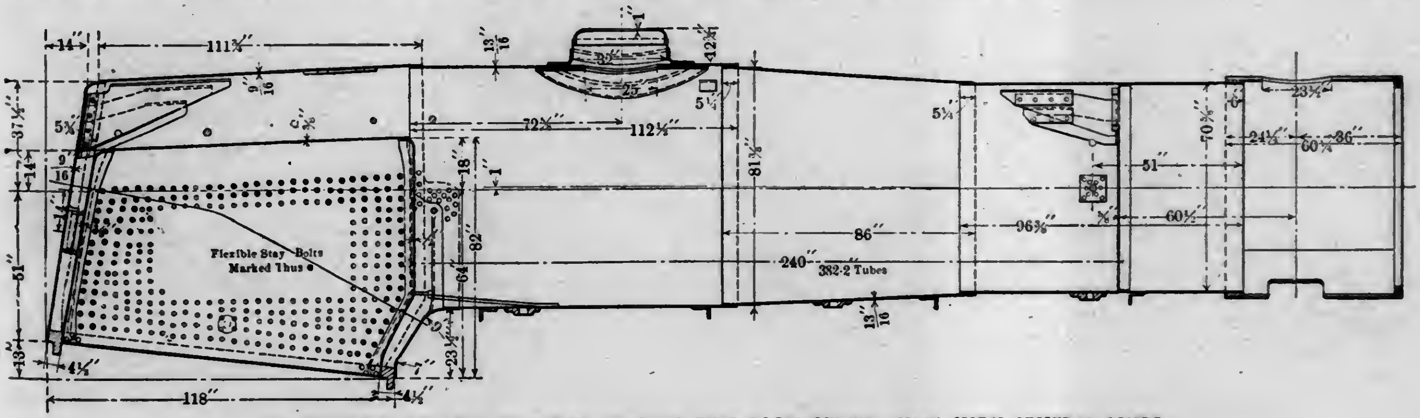
The general dimensions, weights, and ratios are as follows:

GENERAL DATA.

Gauge	4 ft. 8½ in.
Service	Passenger
Fuel	Bit. coal
Tractive effort	29,200 lbs.
Weight in working order	266,000 lbs.
Weight on drivers	171,500 lbs.
Weight of engine and tender in working order	430,000 lbs.
Wheel base, driving	14 ft.
Wheel base, total	36 ft. 6 in.
Wheel base, engine and tender	67 ft. 11 in.

RATIOS.

Weight on drivers ÷ tractive effort	5.84
Total weight ÷ tractive effort	9.11
Tractive effort x diam. drivers ÷ heating surface	550.00
Total heating surface ÷ grate area	74.50
Firebox heating surface ÷ total heating surface, per cent	5.35
Weight on drivers ÷ total heating surface	40.70
Total weight ÷ total heating surface	63.10



LONGITUDINAL SECTION OF BOILER—PACIFIC TYPE LOCOMOTIVES—NEW YORK CENTRAL LINES.

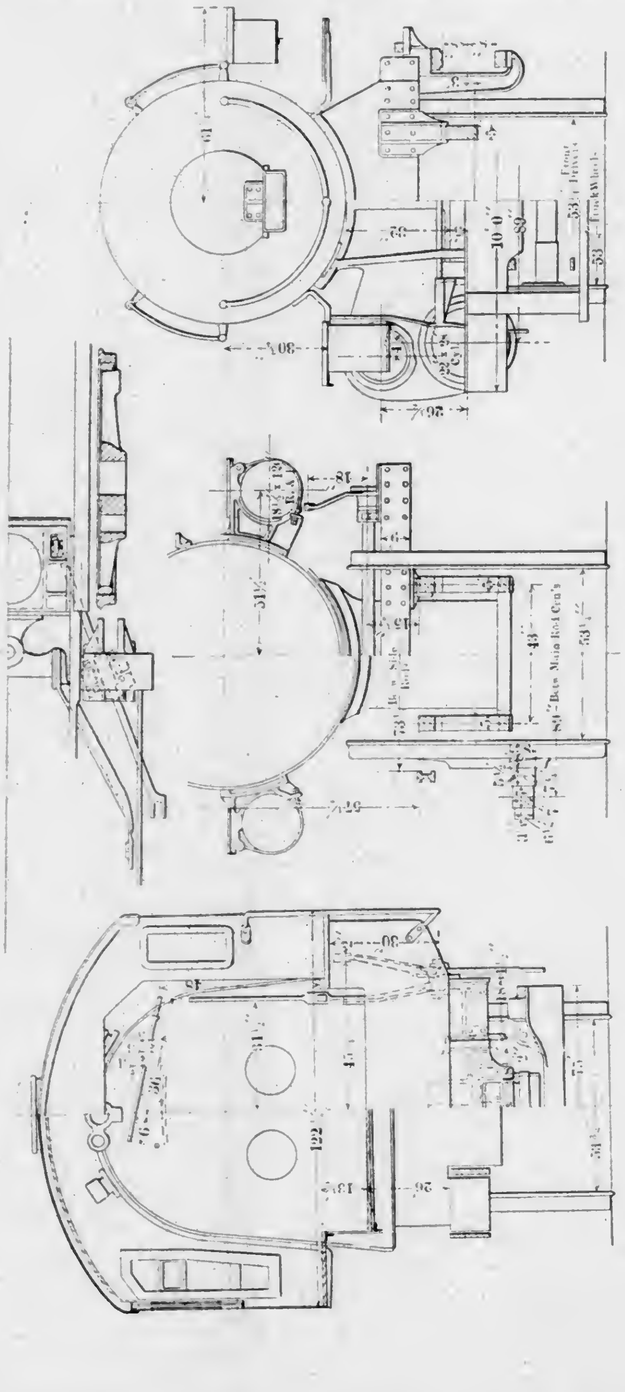
HEAVY PACIFIC TYPE PASSENGER LOCOMOTIVE.

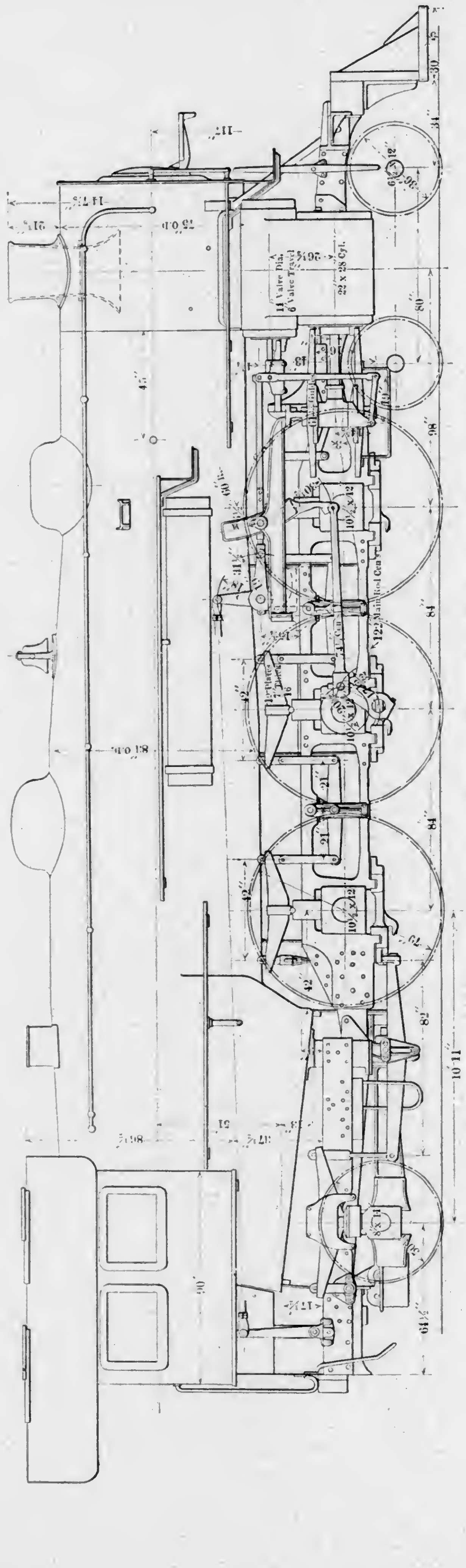
NEW YORK CENTRAL LINES.

There has recently been finished at the Schenectady Works of the American Locomotive Company, 40 Pacific type passenger locomotives for the New York Central & Hudson River Railroad, which are the heaviest ever built for this line, and are practically the heaviest passenger locomotives in the world.

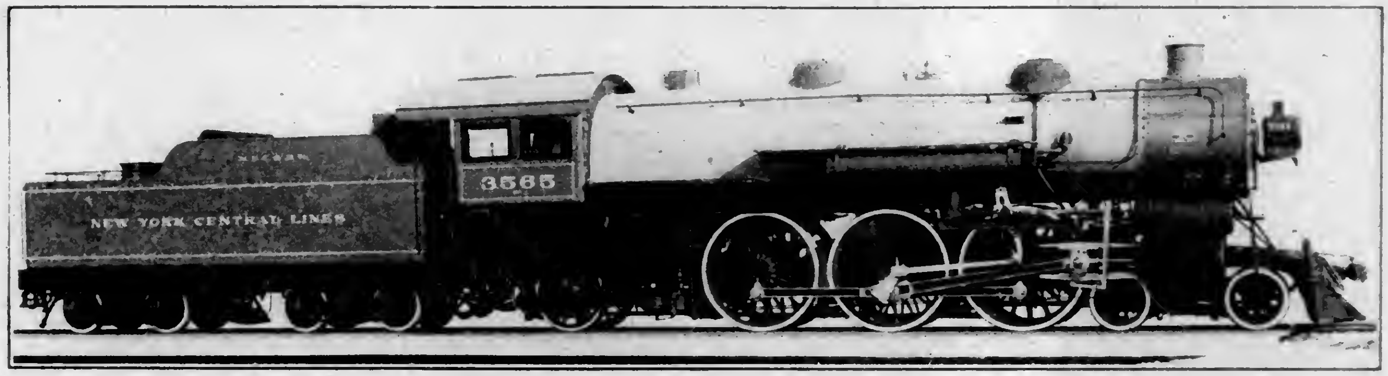
These locomotives are, in all essential details, duplicates of the 25 engines built by the same company last year for the Lake Shore & Michigan Southern Railway, which were illustrated and described on page 365 of the September issue of this journal. Those engines took the place of the Prairie type, as the standard high speed engine on that road, and are now hauling all of the heavier through trains. It is probable that this new class will become the standard type for heavy passenger power on all of the New York Central Lines.

For comparison with previous locomotives of this type, as well as other passenger locomotives, reference should be made to the tables published in connection with a description of a similar locomotive for the Pennsylvania Railroad, page 267 of the July, 1907, issue, the Lake Shore engine above mentioned and the tabular comparison of locomotives published last June. An examination of these comparative tables and of the ratios given in the table below will show that while these locomotives are ex-



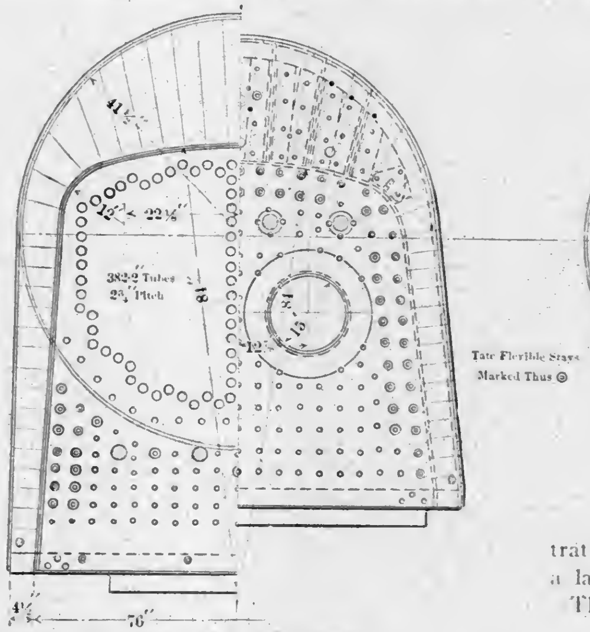


GENERAL ELEVATIONS AND SECTIONS, PACIFIC TYPE LOCOMOTIVE—NEW YORK CENTRAL LINES.



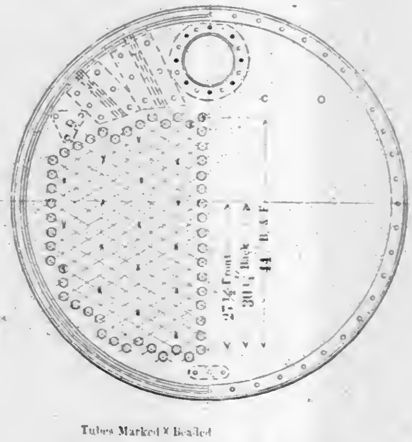
HEAVY PACIFIC TYPE PASSENGER LOCOMOTIVE—NEW YORK CENTRAL LINES.

ceedingly powerful, the power is not clearly indicated by the amount of tractive effort. A theoretical tractive effort of 29,200 lbs. is seemingly small for a locomotive weighing 266,000 lbs., and actually the power of the locomotive lies in its enormous steaming capacity and in its undoubted ability to start heavy trains. The ratio of adhesion of 5.84 shows that there will be no slipping troubles in starting the heavy modern passenger train of 10 to 15 cars even at stations located on curves. The B. D. ratio of 550 is considerably below the average figure for Pacific type locomotives, but is one which has been approached in all of the later designs of passenger locomotives on the New York Central Lines and shows that they certainly will not be deficient in steaming capacity.



SECTION AND ELEVATION OF FIREBOX.

The general construction is shown in the illustrations, as is also the general design of the very large boilers. The Walschaert valve gear is, of course, used, the design being very similar to that applied to the Lake Shore engines, the only noticeable difference being in connecting the reach rod to an upwardly extending arm on the reverse shaft, thus making the eccentric crank pin follow the main pin instead of leading it. The other important features of construction are clearly shown in the illustrations. Some of the more interesting details will be shown in a later issue.



SECTION THROUGH FRONT END.

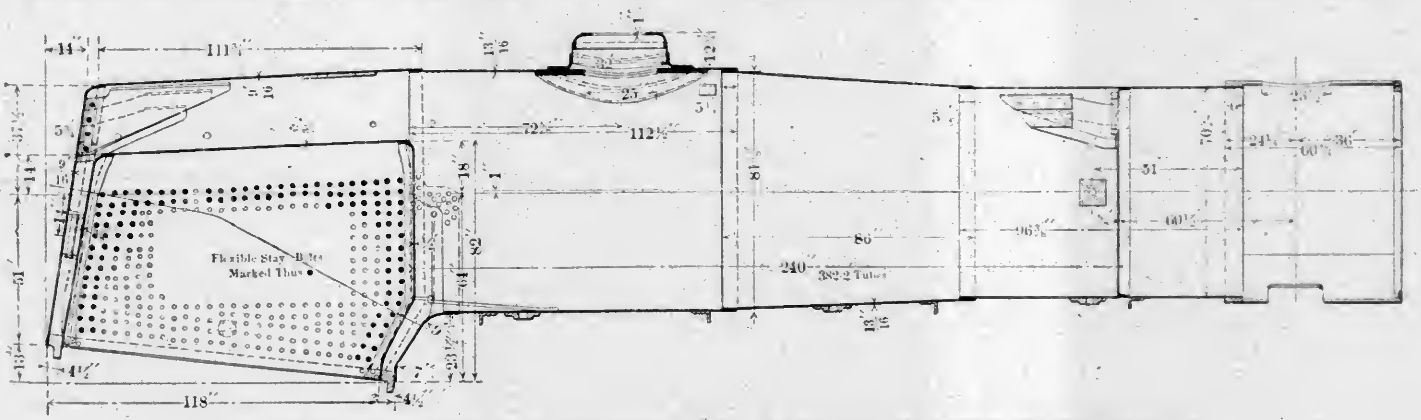
The general dimensions, weights, and ratios are as follows:

GENERAL DATA.

Gauge	4 ft. 8½ in.
Service	Passenger
Fuel	Bit. coal
Tractive effort	29,200 lbs.
Weight in working order	266,000 lbs.
Weight on drivers	171,500 lbs.
Weight of engine and tender in working order	430,000 lbs.
Wheel base, driving	14 ft.
Wheel base, total	36 ft. 6 in.
Wheel base, engine and tender	67 ft. 11 in.

RATIOS.

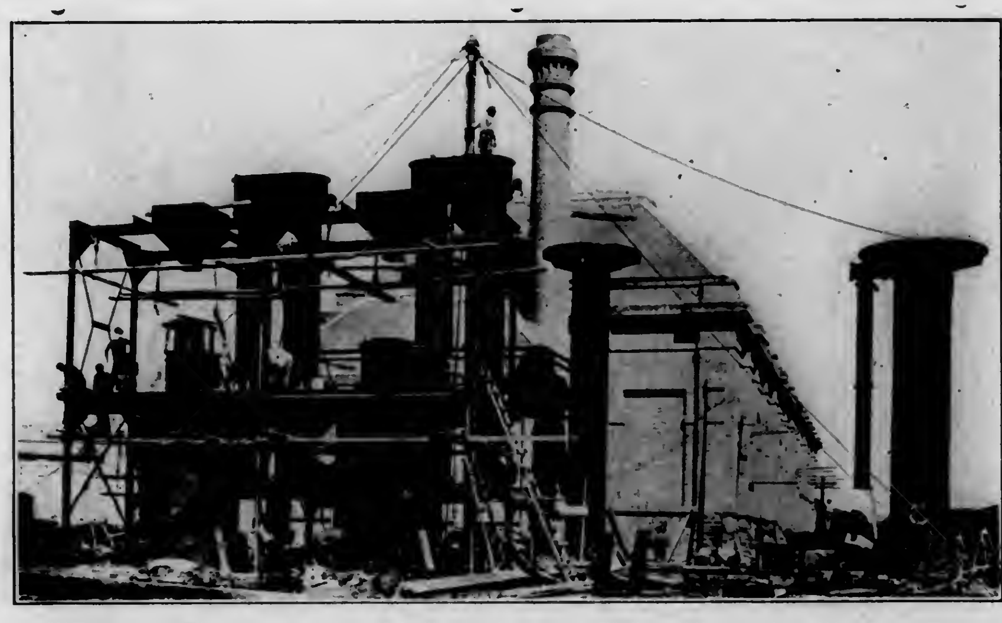
Weight on drivers ÷ tractive effort	5.84
Total weight ÷ tractive effort	9.11
Tractive effort x diam. drivers ÷ heating surface	550.00
Total heating surface ÷ grate area	74.50
Firebox heating surface ÷ total heating surface, per cent	5.35
Weight on drivers ÷ total heating surface	40.70
Total weight ÷ total heating surface	63.10



LONGITUDINAL SECTION OF BOILER—PACIFIC TYPE LOCOMOTIVES—NEW YORK CENTRAL LINES.

Volume both cylinders, cu. ft.	12.32
Total heating surface ÷ vol. cylinders	341.00
Grate area ÷ vol. cylinders	4.58
CYLINDERS.	
Kind	Simple
Diameter and stroke	22 x 28 in.
VALVES.	
Kind	Piston
Diameter	14 in.
Greatest travel	6 in.
Outside lap	1 in.
Inside clearance	1/8 in.
Lead, constant	1/4 in.
WHEELS.	
Driving, diameter over tires	79 in.
Driving, thickness of tires	3½ in.
Driving journals, diameter and length	10½ x 12 in.
Engine truck wheels, diameter	36 in.
Engine truck journals	6½ x 12 in.
Trailing truck wheels, diameter	50¼ in.
Trailing truck journals	8 x 14 in.

BOILER.	
Style	Conical
Working pressure	200 lbs.
Outside diameter of first ring	72 in.
Firebox, length and width	108⅛ x 75¼ in.
Firebox plates, thickness	⅜ & ½ in.
Firebox, water space	4½ in.
Tubes, number and outside diameter	382—2 in.
Tubes, length	20 ft.
Heating surface, tubes	3981.6 sq. ft.
Heating surface, firebox	228.3 sq. ft.
Heating surface, total	4209.9 sq. ft.
Grate area	56.5 sq. ft.
Smokestack, diameter	20 in.
Smokestack, height above rail	14 ft. 7⅞ in.
TENDER.	
Tank	Water Bottom
Frame	13 in. channels
Wheels, diameter	36 in.
Journals, diameter and length	5½ x 10 in.
Water capacity	8,000 gals.
Coal capacity	14 tons



GAS PRODUCERS IN COURSE OF ERECTION—LINIERS POWER HOUSE, BUENOS AYRES WESTERN RY.

PRODUCER GAS POWER FOR RAILWAY SHOPS.

Owing to the extremely high cost of coal in the Argentine Republic it is necessary, in considering the design of power houses of any size, to give the feature of fuel economy a most careful study. About two years ago two of the largest railway systems in that country found it desirable to build new power plants, one in connection with a complete and modern repair plant and the other for lighting and power on docks and yards as well as for the shops. Both of these companies decided to drive their generators by gas engines, working on producer gas obtained from bituminous slack, which could be purchased at a cost of $5.50 gold a ton. A thorough canvass of the subject indicated that a lower cost per k.w. hour could be obtained in this way than in any other, outside of water power, which was not available. Two years' operation of these plants have shown the soundness of the decision, and, in spite of the handicap of expensive fuel, these plants are producing current at a cost which compares very favorably with the best railway plants in this country.

The plant of the Buenos Ayres Western Railway forms part of a new locomotive and car repair plant at Liniers. This railway was the first in the Argentine Republic, being inaugurated in 1857 with a line 6¼ miles long, operated by one locomotive and four cars. In 1907 it had a line 1,160 miles in length, owned 228 locomotives, 209 passenger coaches and 5,562 freight cars. The gauge, like most of the railways in that country, is 5 ft. 6 in.

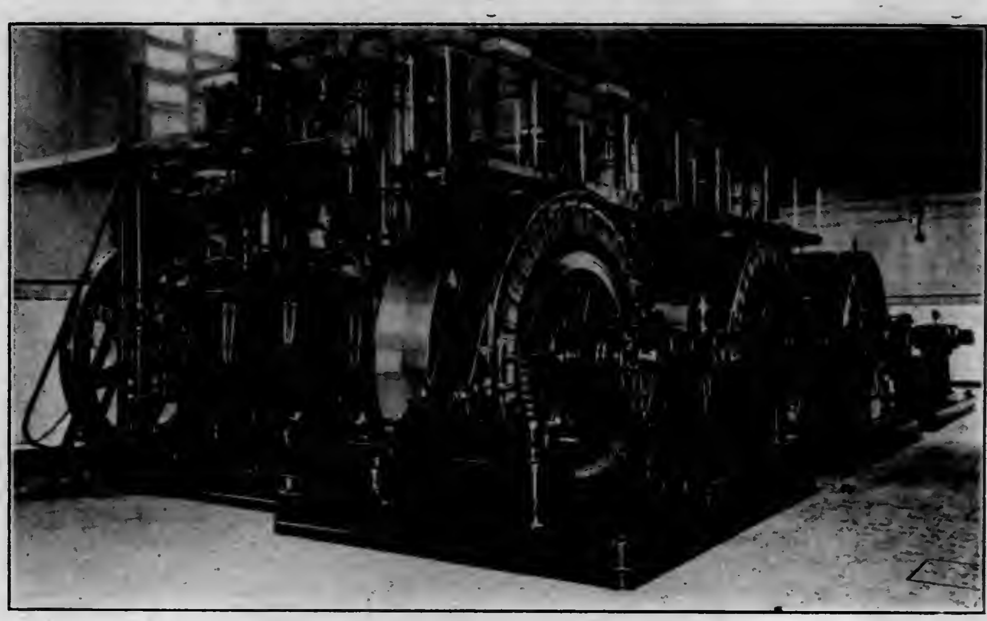
The new shops are situated about nine miles from the center of the city of Buenos Ayres and occupy a plot of ground of about 57 acres area. The plant includes coach and car building and repair shops, locomotive erecting shop, boiler, machine, blacksmith and wheel turning shops, iron and brass foundries, copper, tinsmith and painting departments, saw mill and buildings for the construction and repair of steel frame cars, besides extensive buildings for the storage of rough and finished material, storehouses, office building, power plant, etc. The locomotive section of the plant is equipped for the erection and maintenance of locomotives, but not for building, since all locomotives are ordered from either England or the United States and can be imported free of duty. Since none of the raw materials entering into locomotive construction are produced in this country it is not considered economical to maintain a plant for building locomotives.

The machinery throughout the works is electrically driven from a 440-volt, three-phase distributing system. The power is furnished by a central power station, which in addition to supplying energy for power and light also furnishes compressed air for operating pneumatic tools, hoists, air lifts in deep artesian wells and pumps for supplying all of the water used throughout the works.

The contractors for the complete electrical, gas engine and producer plant were the British Westinghouse Electric & Mfg. Co., Ltd. Most of the gas-engine equipment was manufactured by the Westinghouse Machine Co., of East Pittsburg.

The work of erection of the plant was started on December 1, 1904, by the erection of the engines and gas producer plant. All of the buildings are constructed of native hand-made brick and have saw-tooth roofs. Where possible the roofs are designed to get the southern light, but in some cases it was necessary to have the windows face the east. The works are divided by a wide central avenue running north and south. The west side is devoted to the woodworking department, coach and car building, storehouses, etc., and the east side is given up to a metal working department, locomotive erecting and repair shops, waterworks and power plant.

The woodworking department includes a general storehouse measuring 112 x 275 ft., having a charging and discharging platform provided with an electric walking crane of 3 tons capacity. The car building and repair shop is 230 x 223 ft. and has ten tracks passing through it. These continue outside of the building for some distance at the west end, forming a large repair yard. On the opposite side of the building the tracks extend only a short distance to a motor driven transfer table, which serves this group of buildings as well as the saw mill and passenger car building department adjoining it. This table is 70 ft. long and has a carrying capacity of 45 tons. It runs on seven lines of rails set slightly lower than the crossing tracks, thus eliminating the usual transfer table pit and permitting easy communication between the woodworking and metal working departments. The table is driven through gearing by a 10 h.p. induction motor, obtaining its current from overhead trolley wires. The saw mill, carpenter shop and coach building shop are grouped together in one building measuring 334 x 223 ft., each shop being separated by interior division walls. In the saw mill the machines are quite largely motor driven with most of the motors placed in concrete pits below the floor. The motor equipment in this shop comprises 23 motors aggregating 307 h.p., the largest motor being 60 h.p. In the carpenter, or cabinet making shop, are three electric tank heaters for glue pots.



GAS ENGINES AND GENERATORS, LINIERS POWER HOUSE.

The departments on the west side of the works are, with the exception of the painting and varnishing departments and the power house, grouped into one large building measuring 550 x 275 ft. This is divided by interior division walls into the erecting shop 126 x 300 ft.; machine shop, 140 x 126 ft.; foundry, 126 x 123 ft.; blacksmith shop, 126 x 110 ft., with an L of 63 x 60 ft.; boiler shop, 49 x 146 ft.; wheel shop, truck shop, tinsmith shop, etc. The machinery in these different shops is very largely driven on the group system from short sections of line shaft belted to motors. Overhead traveling cranes are extensively used and are supplemented by air hoists and trolleys wherever needed. The blast for the blacksmith shop and foundry is obtained from an electrically driven fan, as is also the exhaust for the Buffalo down-draft forges. The erecting shop, the interior of which is shown in one of the illustrations, has a capacity for 36 locomotives and is served by four 30-ton electric cranes, two in each bay. These cranes are of a sufficient height to enable one locomotive to be lifted and carried over another. The tracks are arranged on the longitudinal principle. The boiler and machine shops have a complete modern equipment suited to the size of the erecting shop.

The painting and varnishing department is in a separate building which measures 126 x 223 ft., equipped with seven tracks. Since the atmospheric conditions in this country are for the greater part of the time unfavorable for the drying of paints and varnishes a complete plant for artificial ventilation has been installed in this building. The heated fresh air is introduced through an extensive system of galvanized pipes to all parts of the building, the outlet being near the roof. The foul air is removed from near the floor level by numerous flues passing up through the roof.

The water supply is obtained from artesian wells about 160 ft. deep, the water being forced up by air pressure into a cistern at the surface. From this cistern it is pumped to elevated tanks. These tanks have a combined capacity of 110,000 gallons at an elevation of 60 ft. There are two separate water stations, one of which has four pumping units, all electrically driven, and the other two pumps, one being electrically driven and the other a duplex steam pump. There are 78 fire hydrants located throughout the works.

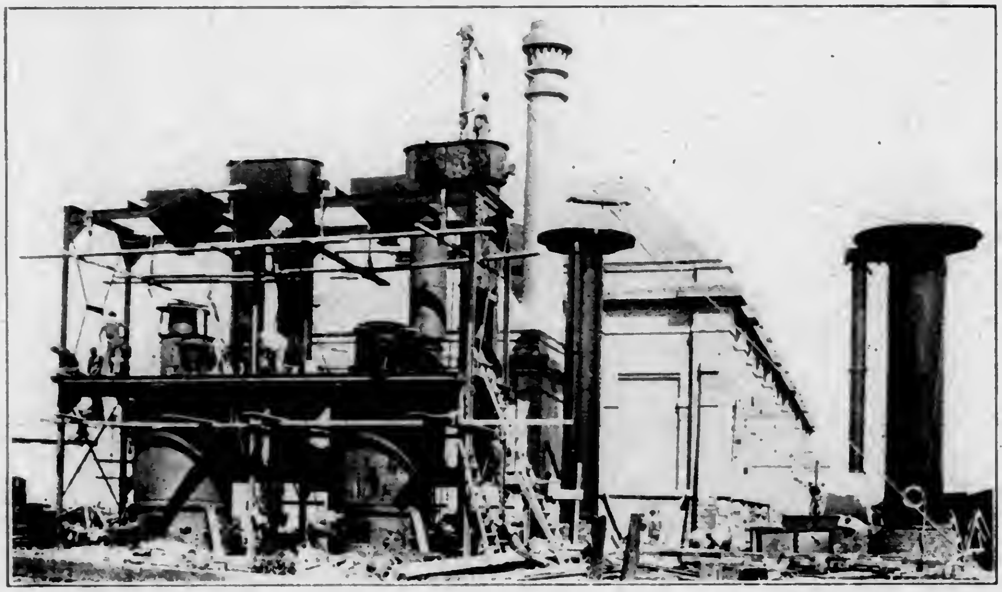
Power Plant.—The power plant is situated at the extreme eastern end of the works and includes a power house of brick construction with a mansard roof which measures 200 x 42 ft. This building is divided by partition walls 14 ft. high into three large rooms, there being one department for the gas plant machinery, another for the engine and dynamo equipment and the third for the air compressors, in addition to offices, work shop and storeroom.

The gas producer plant is located outside of the power house and is not under cover. It consists of two water sealed Mond bituminous producers 6 ft. inside diameter, each capable of gasifying ten tons of coal in 24 hours, together with the accompanying purifying and cleansing apparatus. These producers, which are shown in course of erection in one of the illustrations, are placed close together and surrounded by columns which support the staging carrying the coal bunkers, coal elevator and conveyor, superheater tower and charging platform. The superheater towers or regenerators are placed at the back of the producers, on the side toward the building, and rise to a height of 40 ft. above the ground level. The coal is brought in in barrows and dumped into a hopper at the foot of an elevator where it passes through a feeding device to the elevator buckets and is raised, discharging into a conveyor, which in turn discharges it into either bunker, as desired. From this point it moves altogether by gravity. The gas leaving the top of the producer passes first through the superheater tower, then through washers, gas tower, gasometer, washing fans, sawdust scrubber and condenser in each of which impurities are removed and by the time it reaches the engine it is a clean colorless gas. The process of forming the gas is, briefly, as follows:

A Korting blower of the injector type, the operation of which is controlled automatically by the gasometer, provides a blast of

Volume both cylinders, cu. ft.	12.32
Total heating surface ÷ vol. cylinders	341.00
Grate area ÷ vol. cylinders	1.58
CYLINDERS.	
Kind	Simple
Diameter and stroke	22 x 28 in.
VALVES.	
Kind	Piston
Diameter	11 in.
Greatest travel	6 in.
Outside lap	1 in.
Inside clearance	[illegible] in.
Lead, constant	[illegible] in.
WHEELS.	
Driving, diameter over tires	79 in.
Driving, thickness of tires	3½ in.
Driving journals, diameter and length	10½ x 12 in.
Engine truck wheels, diameter	36 in.
Engine truck journals	6½ x 12 in.
Trailing truck wheels, diameter	50[illegible] in.
Trailing truck journals	8 x 11 in.

BOILER.	
Style	Conical
Working pressure	200 lbs.
Outside diameter of first ring	72 in.
Firebox, length and width	108⅛ x 75¼ in.
Firebox plates, thickness	⅜ & ½ in.
Firebox, water space	4½ in.
Tubes, number and outside diameter	382—2 in.
Tubes, length	20 ft.
Heating surface, tubes	3981.6 sq. ft.
Heating surface, firebox	228.3 sq. ft.
Heating surface, total	4209.9 sq. ft.
Grate area	56.5 sq. ft.
Smokestack, diameter	20 in.
Smokestack, height above rail	14 ft. 7⅞ in.
TENDER.	
Tank	Water Bottom
Frame	13 in. channels
Wheels, diameter	36 in.
Journals, diameter and length	5½ x 10 in.
Water capacity	8,000 gals.
Coal capacity	14 tons



GAS PRODUCERS IN COURSE OF ERECTION—LINIERS POWER HOUSE, BUENOS AYRES WESTERN RY.

PRODUCER GAS POWER FOR RAILWAY SHOPS.

Owing to the extremely high cost of coal in the Argentine Republic it is necessary, in considering the design of power houses of any size, to give the feature of fuel economy a most careful study. About two years ago two of the largest railway systems in that country found it desirable to build new power plants, one in connection with a complete and modern repair plant and the other for lighting and power on docks and yards as well as for the shops. Both of these companies decided to drive their generators by gas engines, working on producer gas obtained from bituminous slack, which could be purchased at a cost of $5.50 gold a ton. A thorough canvass of the subject indicated that a lower cost per k.w. hour could be obtained in this way than in any other, outside of water power, which was not available. Two years' operation of these plants have shown the soundness of the decision, and, in spite of the handicap of expensive fuel, these plants are producing current at a cost which compares very favorably with the best railway plants in this country.

The plant of the Buenos Ayres Western Railway forms part of a new locomotive and car repair plant at Liniers. This railway was the first in the Argentine Republic, being inaugurated in 1857 with a line 6¼ miles long, operated by one locomotive and four cars. In 1907 it had a line 1,100 miles in length, owned 228 locomotives, 209 passenger coaches and 5,562 freight cars. The gauge, like most of the railways in that country, is 5 ft. 6 in.

The new shops are situated about nine miles from the center of the city of Buenos Ayres and occupy a plot of ground of about 57 acres area. The plant includes coach and car building and repair shops, locomotive erecting shop, boiler, machine, blacksmith and wheel turning shops, iron and brass foundries, copper, tinsmith and painting departments, saw mill and buildings for the construction and repair of steel frame cars, besides extensive buildings for the storage of rough and finished material, storehouses, office building, power plant, etc. The locomotive section of the plant is equipped for the erection and maintenance of locomotives, but not for building, since all locomotives are ordered from either England or the United States and can be imported free of duty. Since none of the raw materials entering into locomotive construction are produced in this country it is not considered economical to maintain a plant for building locomotives.

The machinery throughout the works is electrically driven from a 440 volt, three-phase distributing system. The power is furnished by a central power station, which in addition to supplying energy for power and light also furnishes compressed air for operating pneumatic tools, hoists, air lifts in deep artesian wells and pumps for supplying all of the water used throughout the works.

The contractors for the complete electrical, gas engine and producer plant were the British Westinghouse Electric & Mfg. Co., Ltd. Most of the gas-engine equipment was manufactured by the Westinghouse Machine Co., of East Pittsburg.

The work of erection of the plant was started on December 1, 1904, by the erection of the engines and gas producer plant. All of the buildings are constructed of native hand-made brick and have saw-tooth roofs. Where possible the roofs are designed to get the southern light, but in some cases it was necessary to have the windows face the east. The works are divided by a wide central avenue running north and south. The west side is devoted to the woodworking department, coach and car building, storehouses, etc., and the east side is given up to a metal working department, locomotive erecting and repair shops, waterworks and power plant.

The woodworking department includes a general storehouse measuring 112 x 275 ft., having a charging and discharging platform provided with an electric walking crane of 3 tons capacity. The car building and repair shop is 230 x 223 ft. and has ten tracks passing through it. These continue outside of the building for some distance at the west end, forming a large repair yard. On the opposite side of the building the tracks extend only a short distance to a motor driven transfer table, which serves this group of buildings as well as the saw mill and passenger car building department adjoining it. This table is 70 ft. long and has a carrying capacity of 45 tons. It runs on seven lines of rails set slightly lower than the crossing tracks, thus eliminating the usual transfer table pit and permitting easy communication between the woodworking and metal working departments. The table is driven through gearing by a 10 h.p. induction motor, obtaining its current from overhead trolley wires. The saw mill, carpenter shop and coach building shop are grouped together in one building measuring 334 x 223 ft., each shop being separated by interior division walls. In the saw mill the machines are quite largely motor driven with most of the motors placed in concrete pits below the floor. The motor equipment in this shop comprises 23 motors aggregating 307 h.p., the largest motor being 60 h.p. In the carpenter, or cabinet making shop, are three electric tank heaters for glue pots.

The departments on the west side of the works are, with the exception of the painting and varnishing departments and the power house, grouped into one large building measuring 550 x 275 ft. This is divided by interior division walls into the erecting shop 126 x 300 ft.; machine shop, 140 x 126 ft.; foundry, 126 x 123 ft.; blacksmith shop, 126 x 110 ft., with an L of 63 x 60 ft.; boiler shop, 49 x 146 ft.; wheel shop, truck shop, tinsmith shop, etc. The machinery in these different shops is very largely driven on the group system from short sections of line shaft belted to motors. Overhead traveling cranes are extensively used and are supplemented by air hoists and trolleys wherever needed. The blast for the blacksmith shop and foundry is obtained from an electrically driven fan, as is also the exhaust for the Buffalo down-draft forges. The erecting shop, the interior of which is shown in one of the illustrations, has a capacity for 36 locomotives and is served by four 30-ton electric cranes, two in each bay. These cranes are of a sufficient height to enable one locomotive to be lifted and carried over another. The tracks are arranged on the longitudinal principle. The boiler and machine shops have a complete modern equipment suited to the size of the erecting shop.

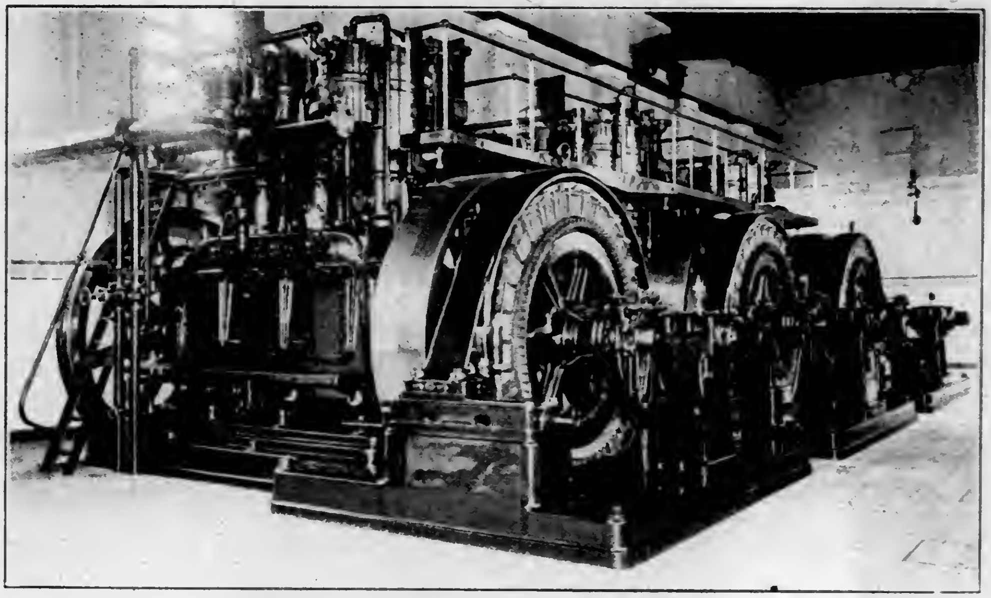
The painting and varnishing department is in a separate building which measures 126 x 223 ft., equipped with seven tracks. Since the atmospheric conditions in this country are for the greater part of the time unfavorable for the drying of paints and varnishes a complete plant for artificial ventilation has been installed in this building. The heated fresh air is introduced through an extensive system of galvanized pipes to all parts of the building, the outlet being near the roof. The foul air is removed from near the floor level by numerous flues passing up through the roof.

The water supply is obtained from artesian wells about 160 ft. deep, the water being forced up by air pressure into a cistern at the surface. From this cistern it is pumped to elevated tanks. These tanks have a combined capacity of 110,000 gallons at an elevation of 60 ft. There are two separate water stations, one of which has four pumping units, all electrically driven, and the other two pumps, one being electrically driven and the other a duplex steam pump. There are 78 fire hydrants located throughout the works.

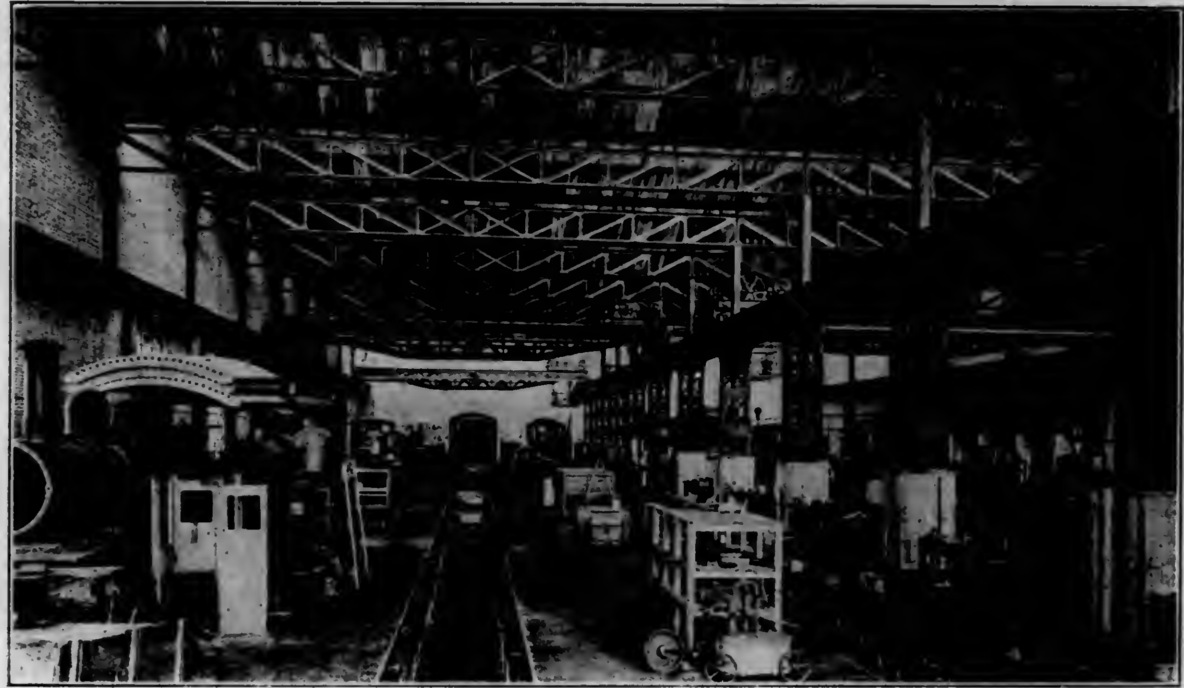
Power Plant—The power plant is situated at the extreme eastern end of the works and includes a power house of brick construction with a mansard roof which measures 200 x 42 ft. This building is divided by partition walls 14 ft. high into three large rooms, there being one department for the gas plant machinery, another for the engine and dynamo equipment and the third for the air compressors, in addition to offices, work shop and storeroom.

The gas producer plant is located outside of the power house and is not under cover. It consists of two water sealed Mond bituminous producers 6 ft. inside diameter, each capable of gasifying ten tons of coal in 24 hours, together with the accompanying purifying and cleansing apparatus. These producers, which are shown in course of erection in one of the illustrations, are placed close together and surrounded by columns which support the staging carrying the coal bunkers, coal elevator and conveyor, superheater tower and charging platform. The superheater towers or regenerators are placed at the back of the producers, on the side toward the building, and rise to a height of 40 ft. above the ground level. The coal is brought in in barrows and dumped into a hopper at the foot of an elevator where it passes through a feeding device to the elevator buckets and is raised, discharging into a conveyor, which in turn discharges it into either bunker, as desired. From this point it moves altogether by gravity. The gas leaving the top of the producer passes first through the superheater tower, then through washers, gas tower, gasometer, washing fans, sawdust scrubber and condenser in each of which impurities are removed and by the time it reaches the engine it is a clean colorless gas. The process of forming the gas is, briefly, as follows:

A Korting blower of the injector type, the operation of which is controlled automatically by the gasometer, provides a blast of



GAS ENGINES AND GENERATORS, LINIERS POWER HOUSE.



INTERIOR OF ERECTING SHOP, LINIERS SHOPS—BUENOS AYRES WESTERN RY.

air which passes first through an air heating tower in which there is a stream of hot water passing and there takes up a certain amount of heat and moisture. This mixture is then conveyed along the mains to the superheaters, which consist of two tubes forming an annular space through which the air and steam passes. The hot gases from the producer pass down through the inner tube in the opposite direction from the air and steam and a large amount of its heat is transferred to them. From this the hot air and steam pass through a similar annular space around the producer and downward below the fire bars. The gas after passing through the superheater goes to a washer having two dashers revolving at a good speed, which throw the water contained in the washer into a fine spray through which the gas passes, thereby being cleaned and at the same time giving up a large amount of heat. It is then taken to the gas cooling tower, consisting of a cylindrical vessel packed with small earthenware tubes. The water which heats the air in the air tower obtains its heat by being pumped through this gas cooling tower and thus simply transforms the heat from the gas to the air, operating continually. On leaving the cooling tower the gas is taken to a gasometer and thence to two fans which by their centrifugal force throw out any particles of tar and dust, etc., being aided by the injection of a stream of cold water into the interior of the fan. From this point it passes to the sawdust scrubbers, and is ready for use in the gas engines.

The pumps for circulating the water and the blowers for supplying the blast are driven by steam. The gas washing fans are belted to the line shaft, which supplies power for the coal elevator. This shaft is driven by a Marshall upright steam engine and from it is also belted a small sparking dynamo to start the main engines. After the main engines are started, however, the shaft is driven by a 10 h.p. electric motor. Another Marshall upright steam engine is provided which is belted to a direct-current generator, furnishing electric light for sections of the plant, when the main power station is not working, and also supplies power for an electric pump.

The gas engines, of which there are four, are of the Westinghouse three-cylinder type, direct connected to Westinghouse three-phase alternators. These engines work on the four-cycle principle, three being of 250 brake h.p. capacity, with cylinders 19 x 22, coupled to 150 kw. generators. These operate at 200 r.p.m. The fourth unit is a 125 h.p. engine with 15 x 14 in. cylinders coupled to a 75 kw. generator, operating at 272 r.p.m. The exciting current is furnished by a motor generating set consisting of a 60 h.p. induction motor coupled to a 40 kw. 125-volt dynamo. For starting, exciting current is taken from the steam-driven lighting set.

There are a total of 93 motors aggregating 1071½ h.p. in the whole plant. Practically all of these are induction motors.

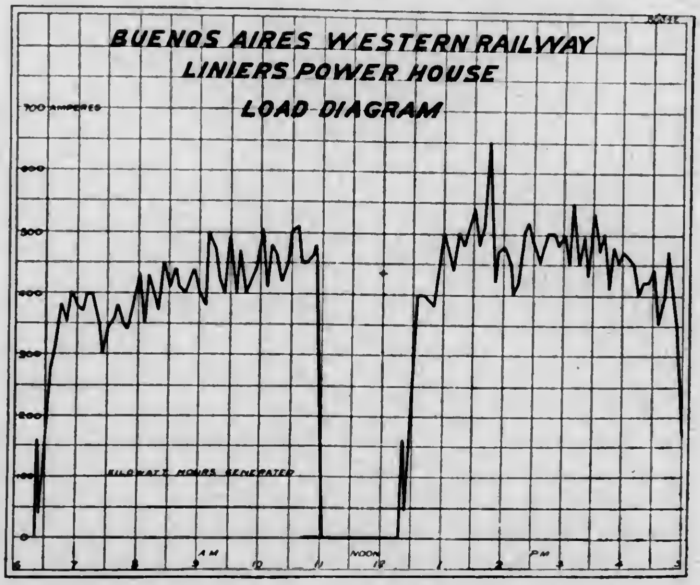
The air compressing plant consists of two Ingersoll-Sargeant duplex compound compressors belted to 80 h.p. induction motors; each compressor has a capacity of 350 cu. ft. of free air per minute. They furnish 90 lbs. pressure.

There are also two gas engine driven air compressors for supplying a pressure in the storage tanks for starting the large engines. There are four of these tanks, all approximately 40 cu. ft. capacity, which have a pressure of 190 lbs.

The power distribution is all from three-phase circuits at 440 volts, 50 cycles. One of the illustrations shows the load curves on the station for 24 hours and give a very good idea of the variation which occurs.

GREAT SOUTHERN RAILWAY PLANT.

The producer gas plant for the power station of the Buenos Ayres Great Southern Railway, which in addition to furnishing power for the repair shops also furnishes light and power for the docks and freight and passenger stations along the line for a distance of about 12½ miles, is somewhat larger but of the same type as that for the Western Railway above described. There are in this station four Mond producers, 5 ft. inside diameter,



and the coal is dumped from the cars directly into the elevator boot. In the power house there are six Westinghouse vertical, three cylinder, single acting gas engines, each with a nominal output of 250 h.p., direct connected to Westinghouse three-phase 50-cycle, 440-volt alternators, of 150 kw. each. From the power plant the current is distributed by overhead transmission lines to the repair shops at 440 volts for power and 110 volts for lighting. Westinghouse three-phase, type C, induction motors are used throughout the plant. The power for use at more distant points is stepped up from 440 volts to 6600 volts. It is transmitted over a high tension system of underground wires to the several sub-stations, where it is again stepped down. At one of the substations there are two 400 kw. Westinghouse rotary converters for supplying direct current at 550 volts for the cranes, capstans, grain elevators, etc., along the docks.

This plant was put into service March 14, 1904, and during the first six months there were three stoppages, the whole amounting to nine minutes, the delays being principally caused by an accumulation of water in the gas mains. From that time to the present, however, there has been no delay of any kind.

The number of men employed at present in working the plant for 24 hours a day, with five engines running from 6.40 A. M. to 4.15 P. M., two from 4.15 to 12.00 P. M. and two from 12.00 to 6.40 A. M. is as follows: Seven producer men, three stokers, two laborers, three engineers, two oilers, three switchboard attendants, one fitter and two boys. The men work in eight-hour shifts. The monthly pay-roll for the 23 hands amounts to $1,113 gold. The engine room staff, it will be seen, is not more than would be required for a steam driven plant, but the gas plant necessitates nearly twice as many men as a steam plant of the same capacity, but it must be taken into considertion that a plant 50 per cent. larger could be operated by the same staff.

The average coal consumption during the past six months, including all losses from the time it leaves the ship, amounted to 3.1 lbs. per kw. hour, but as low as 2.1 lbs. per kw. hour is constantly reached with the day load.

The working cost per kw. hour for a period of six months with coal taken at $5.50 gold per ton is shown in the following table:

	Day.	Night.	Average.
Fuel	$0.0052	$0.0088	$0.0076
Oil, waste, water and stores	0.0010	0.0020	0.0013
Repairs and renewals	0.0012	......	0.0012
Wages	0.0048	0.0098	0.0070
Total	$0.0122	$0.0206	$0.0171

VESSELS BUILT IN 1907.—The output of the world's shipyards for the year 1907 was 1,930 vessels of over 100 tons displacement, with an aggregate of 3,099,299 tons. The tonnage of the vessels built in the United States amounted to 474,675 tons, which is 33,400 tons greater than the output for the previous year. Of the total tonnage of the vessels built in this country, considerably more than half was constructed for the Great Lakes.—*Machinery.*

VALUE OF TECHNICAL JOURNALS.—It is a curious and interesting commentary on modern scientific and industrial development that book making cannot keep pace with it. The surgeon can learn the groundwork of his profession from recognized text-books, but to keep abreast of the best current practice he must either see that practice, or hear it described, or read of it in the technical publications devoted to that alone; the lawyer can pass his bar examinations on the basis of his theoretic instruction at the law school, but to win cases he must read cases, as fast as decisions are handed down. The same thing has always been true of the work of the civil and the mechanical engineer; certain standard books on bridge design and on locomotive design have collected together a great group of cardinal principles derived from two generations of practical experience, but no text-book has ever yet or will ever be able to contain a full record of progress as it is illustrated by the best current practice—a record corresponding to the cases which the lawyer studies and also to the cases of a different kind which the surgeon studies. As rule-of-thumb methods in engineering work have more and more given way to scientific methods it has been more and more necessary for the engineer to know just what was being done simultaneously in all parts of the world.—*The Railroad Gazette.*

FOREIGN CAR REPAIR BILLS.

BY J. E. EPLER.*

The foreign car repair bill is an item in the income account of a railroad that has not received the attention it deserves. The object of this article is to present an improvement on the old method of instructing repairmen in making M.C.B. repair stubs and to prevent bills from being returned to the maker by the accounting office.

The method proposed should bring about more accurate results and a minimum number of incorrect bills. It is a very easy matter to find fault with a bill after it is made, especially if the fault-finder is seated at a desk surrounded with books on rulings, exceptions and decisions, but it is an altogether different proposition for the man in the repair yard, who is making out the original bill, and knows little more than his standard book of rules tells him.

This man is usually pressed for time; quite frequently has had to place his own interpretation on a thousand and one rulings as to how bills should be made, and quite often has never read the rules. In his rather crude manner he makes the bill, stating merely that he has applied a bolt: "Bolts are bolts anyway and what is the difference?" Sometimes he is hurried and hopes the bill may go through, but does not care if it is returned to him for correction later. He will then probably have more time to patch it up. Perhaps he is painstaking and thinks he should give information that proves to be unnecessary. All this tends to increase the work in the auditor's office and hold up bills for correction, sometimes resulting in a loss of the amount billable.

The plan suggested is a simple one. Merely a little pamphlet to be enclosed as an appendix to the regular M.C.B. book. Each article in a car is treated separately. Articles are arranged in alphabetical order and all information on the bill is indicated opposite the article. The following samples will show clearly the method:

- Bolts
  - Carry-iron
    - Number of bolts applied
    - Size of bolts applied
    - End of car
    - Cause of renewal
- Beam
  - Brake
    - Oak
      - Number of beams applied
      - Kind of material
      - Size of material
      - Number and size of bolts applied
      - Solid or trussed beams
      - Amount of paint used
      - End of car
      - Cause of renewal
    - Metal
      - Number of beams applied
      - New or second-hand
      - State name of beam applied
      - Renewed or repaired
      - State whether beam is missing or broken
      - State kind of beam removed
      - Specify part broken
      - End of car
      - Cause of renewal

When making the bill the repairman fills in all information as indicated and cannot very well go astray.

MEETING OF THE A. S. M. E.—The semi-annual meeting of The American Society of Mechanical Engineers will be held in Detroit, Michigan, June 23-26. Among the papers to be presented at this session are "A Method of Cleaning Gas Conduits," by W. D. Mount; "A Method of Checking Conical Pistons for Stress," by Prof. George H. Shepard; "Clutches" with special reference to automobile clutches, by H. Souther; "Horse-Power, Friction Losses, and Efficiencies of Gas and Oil Engines," by Prof. L. S. Marks; "Some Pitot Tube Studies," by Prof. W. D. Gregory; "The Thermal Properties of Superheated Steam," by Prof. R. C. H. Heck; "A Journal Friction Measuring Machine," by Henry Hess; "A By-Product Coke Oven," by W. H. Blauvelt; "Tests of Some High Speed Steam Engines," by F. W. Dean. There will be a symposium upon machinery for conveying materials, with papers by several authorities. The Society for the Promotion of Engineering Education and the Society of Automobile Engineers will also hold their annual meeting in Detroit at this time, which will enable members of each society to participate in the sessions of the others.

* Bonus Expert, Santa Fe.

INTERIOR OF ERECTING SHOP, LINIERS SHOPS—BUENOS AYRES WESTERN RY.

air which passes first through an air heating tower in which there is a stream of hot water passing and there takes up a certain amount of heat and moisture. This mixture is then conveyed along the mains to the superheaters, which consist of two tubes forming an annular space through which the air and steam passes. The hot gases from the producer pass down through the inner tube in the opposite direction from the air and steam and a large amount of its heat is transferred to them. From this the hot air and steam pass through a similar annular space around the producer and downward below the fire bars. The gas after passing through the superheater goes to a washer having two dashers revolving at a good speed, which throw the water contained in the washer into a fine spray through which the gas passes, thereby being cleaned and at the same time giving up a large amount of heat. It is then taken to the gas cooling tower, consisting of a cylindrical vessel packed with small earthenware tubes. The water which heats the air in the air tower obtains its heat by being pumped through this gas cooling tower and thus simply transforms the heat from the gas to the air, operating continually. On leaving the cooling tower the gas is taken to a gasometer and thence to two fans which by their centrifugal force throw out any particles of tar and dust, etc., being aided by the injection of a stream of cold water into the interior of the fan. From this point it passes to the sawdust scrubbers, and is ready for use in the gas engines.

The pumps for circulating the water and the blowers for supplying the blast are driven by steam. The gas washing fans are belted to the line shaft, which supplies power for the coal elevator. This shaft is driven by a Marshall upright steam engine and from it is also belted a small sparking dynamo to start the main engines. After the main engines are started, however, the shaft is driven by a 10 h.p. electric motor. Another Marshall upright steam engine is provided which is belted to a direct-current generator, furnishing electric light for sections of the plant, when the main power station is not working, and also supplies power for an electric pump.

The gas engines, of which there are four, are of the Westinghouse three-cylinder type, direct connected to Westinghouse three-phase alternators. These engines work on the four-cycle principle, three being of 250 brake h.p. capacity, with cylinders 19 x 22, coupled to 150 kw. generators. These operate at 200 r.p.m. The fourth unit is a 125 h.p. engine with 15 x 14 in. cylinders coupled to a 75 kw. generator, operating at 272 r.p.m. The exciting current is furnished by a motor generating set consisting of a 60 h.p. induction motor coupled to a 40 kw. 125-volt dynamo. For starting, exciting current is taken from the steam-driven lighting set.

There are a total of 93 motors aggregating 1071½ h.p. in the whole plant. Practically all of these are induction motors.

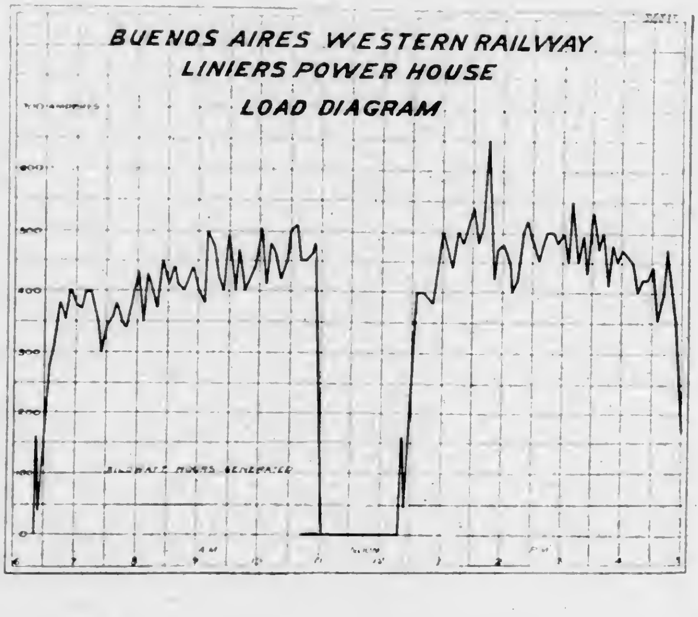
The air compressing plant consists of two Ingersoll-Sargeant duplex compound compressors belted to 80 h.p. induction motors; each compressor has a capacity of 350 cu. ft. of free air per minute. They furnish 90 lbs. pressure.

There are also two gas engine driven air compressors for supplying a pressure in the storage tanks for starting the large engines. There are four of these tanks, all approximately 40 cu. ft. capacity, which have a pressure of 190 lbs.

The power distribution is all from three-phase circuits at 440 volts, 50 cycles. One of the illustrations shows the load curves on the station for 24 hours and give a very good idea of the variation which occurs.

GREAT SOUTHERN RAILWAY PLANT.

The producer gas plant for the power station of the Buenos Ayres Great Southern Railway, which in addition to furnishing power for the repair shops also furnishes light and power for the docks and freight and passenger stations along the line for a distance of about 12½ miles, is somewhat larger but of the same type as that for the Western Railway above described. There are in this station four Mond producers, 5 ft. inside diameter,



and the coal is dumped from the cars directly into the elevator boot. In the power house there are six Westinghouse vertical, three cylinder, single acting gas engines, each with a nominal output of 250 h.p., direct connected to Westinghouse three-phase 50-cycle, 440-volt alternators, of 150 kw. each. From the power plant the current is distributed by overhead transmission lines to the repair shops at 440 volts for power and 110 volts for lighting. Westinghouse three-phase, type C, induction motors are used throughout the plant. The power for use at more distant points is stepped up from 440 volts to 6600 volts. It is transmitted over a high tension system of underground wires to the several sub-stations, where it is again stepped down. At one of the sub-stations there are two 400 kw. Westinghouse rotary converters for supplying direct current at 550 volts for the cranes, capstans, grain elevators, etc., along the docks.

This plant was put into service March 14, 1904, and during the first six months there were three stoppages, the whole amounting to nine minutes, the delays being principally caused by an accumulation of water in the gas mains. From that time to the present, however, there has been no delay of any kind.

The number of men employed at present in working the plant for 24 hours a day, with five engines running from 6.40 A. M. to 4.15 P. M., two from 4.15 to 12.00 P. M. and two from 12.00 to 6.40 A. M. is as follows: Seven producer men, three stokers, two laborers, three engineers, two oilers, three switchboard attendants, one fitter and two boys. The men work in eight-hour shifts. The monthly pay-roll for the 23 hands amounts to $1,113 gold. The engine room staff, it will be seen, is not more than would be required for a steam driven plant, but the gas plant necessitates nearly twice as many men as a steam plant of the same capacity, but it must be taken into considertion that a plant 50 per cent. larger could be operated by the same staff.

The average coal consumption during the past six months, including all losses from the time it leaves the ship, amounted to 3.1 lbs. per kw. hour, but as low as 2.1 lbs. per kw. hour is constantly reached with the day load.

The working cost per kw. hour for a period of six months with coal taken at $5.50 gold per ton is shown in the following table:

	Day.	Night.	Average.
Fuel	$0.0052	$0.0088	$0.0076
Oil, waste, water and stores	0.0010	0.0020	0.0013
Repairs and renewals	0.0012	......	0.0012
Wages	0.0048	0.0098	0.0070
Total	$0.0122	$0.0206	$0.0171

VESSELS BUILT IN 1907.—The output of the world's shipyards for the year 1907 was 1,930 vessels of over 100 tons displacement, with an aggregate of 3,099,299 tons. The tonnage of the vessels built in the United States amounted to 474,675 tons, which is 33,400 tons greater than the output for the previous year. Of the total tonnage of the vessels built in this country, considerably more than half was constructed for the Great Lakes.—*Machinery.*

VALUE OF TECHNICAL JOURNALS.—It is a curious and interesting commentary on modern scientific and industrial development that book making cannot keep pace with it. The surgeon can learn the groundwork of his profession from recognized textbooks, but to keep abreast of the best current practice he must either see that practice, or hear it described, or read of it in the technical publications devoted to that alone; the lawyer can pass his bar examinations on the basis of his theoretic instruction at the law school, but to win cases he must read cases, as fast as decisions are handed down. The same thing has always been true of the work of the civil and the mechanical engineer; certain standard books on bridge design and on locomotive design have collected together a great group of cardinal principles derived from two generations of practical experience, but no text-book has ever yet or will ever be able to contain a full record of progress as it is illustrated by the best current practice—a record corresponding to the cases which the lawyer studies and also to the cases of a different kind which the surgeon studies. As rule-of-thumb methods in engineering work have more and more given way to scientific methods it has been more and more necessary for the engineer to know just what was being done simultaneously in all parts of the world.—*The Railroad Gazette.*

FOREIGN CAR REPAIR BILLS.

BY J. E. EPLER.*

The foreign car repair bill is an item in the income account of a railroad that has not received the attention it deserves. The object of this article is to present an improvement on the old method of instructing repairmen in making M.C.B. repair stubs and to prevent bills from being returned to the maker by the accounting office.

The method proposed should bring about more accurate results and a minimum number of incorrect bills. It is a very easy matter to find fault with a bill after it is made, especially if the fault-finder is seated at a desk surrounded with books on rulings, exceptions and decisions, but it is an altogether different proposition for the man in the repair yard, who is making out the original bill, and knows little more than his standard book of rules tells him.

This man is usually pressed for time, quite frequently has had to place his own interpretation on a thousand and one rulings as to how bills should be made, and quite often has never read the rules. In his rather crude manner he makes the bill, stating merely that he has applied a bolt; "Bolts are bolts anyway and what is the difference?" Sometimes he is hurried and hopes the bill may go through, but does not care if it is returned to him for correction later. He will then probably have more time to patch it up. Perhaps he is painstaking and thinks he should give information that proves to be unnecessary. All this tends to increase the work in the auditor's office and hold up bills for correction, sometimes resulting in a loss of the amount billable.

The plan suggested is a simple one. Merely a little pamphlet to be enclosed as an appendix to the regular M.C.B. book. Each article in a car is treated separately. Articles are arranged in alphabetical order and all information on the bill is indicated opposite the article. The following samples will show clearly the method:

Bolts Carry-iron		Number of bolts applied Size of bolts applied End of car Cause of renewal
Beam Brake	Oak	Number of beams applied Kind of material Size of material Number and size of bolts applied Solid or trussed beams Amount of paint used End of car Cause of renewal
	Metal	Number of beams applied New or second-hand State name of beam applied Renewed or repaired State whether beam is missing or broken State kind of beam removed Specify part broken End of car Cause of renewal

When making the bill the repairman fills in all information as indicated and cannot very well go astray.

MEETING OF THE A. S. M. E.—The semi-annual meeting of The American Society of Mechanical Engineers will be held in Detroit, Michigan, June 23-26. Among the papers to be presented at this session are "A Method of Cleaning Gas Conduits," by W. D. Mount; "A Method of Checking Conical Pistons for Stress," by Prof. George H. Shepard; "Clutches" with special reference to automobile clutches, by H. Souther; "Horse-Power, Friction Losses, and Efficiencies of Gas and Oil Engines," by Prof. L. S. Marks; "Some Pitot Tube Studies," by Prof. W. D. Gregory; "The Thermal Properties of Superheated Steam," by Prof. R. C. H. Heck; "A Journal Friction Measuring Machine," by Henry Hess; "A By-Product Coke Oven," by W. H. Blauvelt; "Tests of Some High Speed Steam Engines," by F. W. Dean. There will be a symposium upon machinery for conveying materials, with papers by several authorities. The Society for the Promotion of Engineering Education and the Society of Automobile Engineers will also hold their annual meeting in Detroit at this time, which will enable members of each society to participate in the sessions of the others.

* Bonus Expert, Santa Fe.

FIRST-CLASS PASSENGER CAR—PHILIPPINE RAILWAY COMPANY.

PASSENGER CARS FOR THE PHILIPPINE RAILWAY.

About two years ago the Philippine Railway Company was granted a perpetual concession for building, equipping and operating between 300 and 400 miles, about equally divided between the islands of Cebu, Panay and Negros. The map shows the proposed routes, the dotted lines indicating mileage not finally located. On June 14, 1906, a party of fifty American engineers, organized by J. G. White & Co., constructing engineers for the railroad, landed in the Philippines. Previous to this time a thorough study of the resources and topography of the island had been made and tentative routes had been mapped out. The engineers divided into several parties and surveys on all three of the islands were pushed as rapidly as possible, so that by November nearly all the main surveys were completed and ground was broken on Cebu.

According to the concessionary contract sections of not less than twenty miles are to be put in operation as completed. Two sections are already in operation upon the island of Cebu and one on Panay. It is expected that the third section on Cebu will be placed in operation about May and the second section on Panay about August of this year. It was feared that it would be necessary to import Chinese labor for building these roads, but the contractors found that by paying a good wage, and furnishing the workmen with a scientifically proportioned diet of good nourishing food, splendid results could be obtained and a first-class lot of workmen are rapidly being developed.

The original concession provided for a 3-foot 6-in. gage; other questions of construction, equipment and operation have been left to the directors of the company, the Technical Board, and the Philippine Commission. For the construction work four 50-ton mogul locomotives were ordered; also 3 light construction engines, fifty 40-ton flat cars and fifty Roger convertible ballast cars. The mogul locomotives have 17 x 24 in. cylinders, 50 inch drivers and a tractive effort of 21,000 lbs. High carbon native lignite coal is used as fuel; diamond stacks and spark arrestors are used to prevent the escape of sparks.

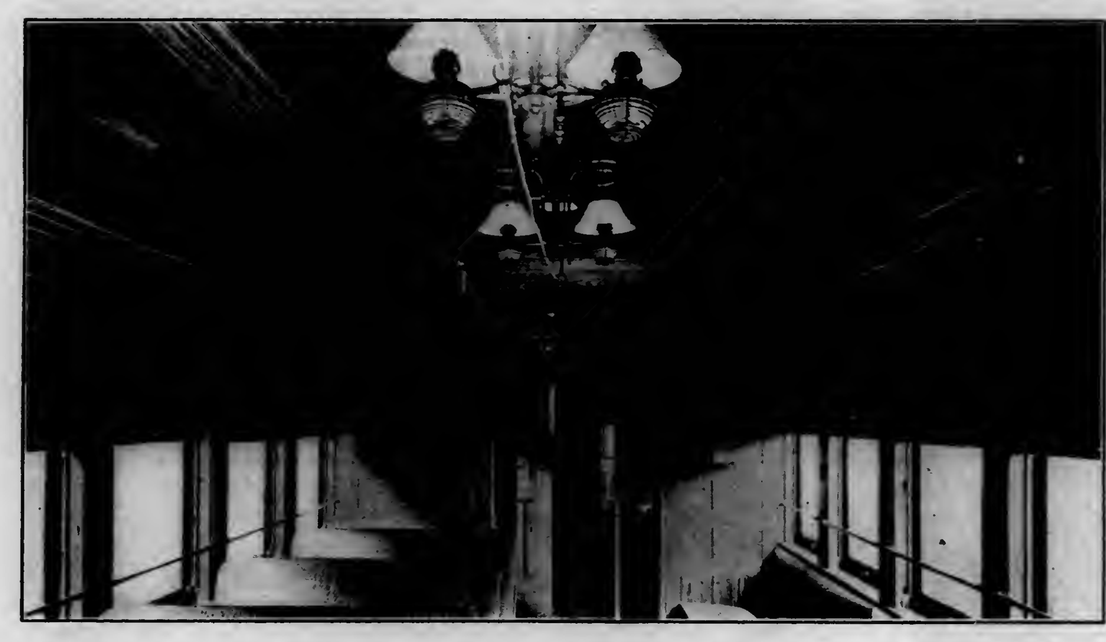
Recently six mogul locomotives were ordered; also four combination parlor and first-class cars, four combination baggage and second-class cars, fifteen second-class cars, forty 10-ton and forty 20-ton box cars. These have been completed and are in transit; meanwhile but one train a day is operated in each direction, accommodations for passengers being provided by roofing over and building seats on the flat cars.

The cars were designed by G. R. Henderson, who acts in the dual capacity of consulting engineer for the railroad company and for the Philippine Commission. The passenger cars were built at the Wilmington, Del., plant of the American Car & Foundry Company. The designer was confronted with several peculiar problems. The construction must be as simple and substantial as possible, and such that what few repairs may be necessary can be made by unskilled labor. The cars must be suitable for a tropical climate and the design must be such that after being erected at the works they could be knocked down into convenient sections for shipment. The details of the different types of the passenger cars, as well as of the freight equipment, have been made interchangeable, as far as possible. The general dimensions of the combination parlor and first-class passenger cars are as follows:

Length over body of car	43 ft. 1½ in.
Width over sun shades	9 ft. 6 in.
Inside length of car	42 ft. 3½ in.
Inside width of car	7 ft. 9¼ in.
Height from side sill to plate	6 ft. 9 in.
Length over underframing	43 ft.
Width over underframing	8 ft. 4½ in.
Distance between truck centers	32 ft. 6 in.
Height from rail to center of coupler	2 ft. 10 in.
Height from rail to top of platform	4 ft. 2 in.

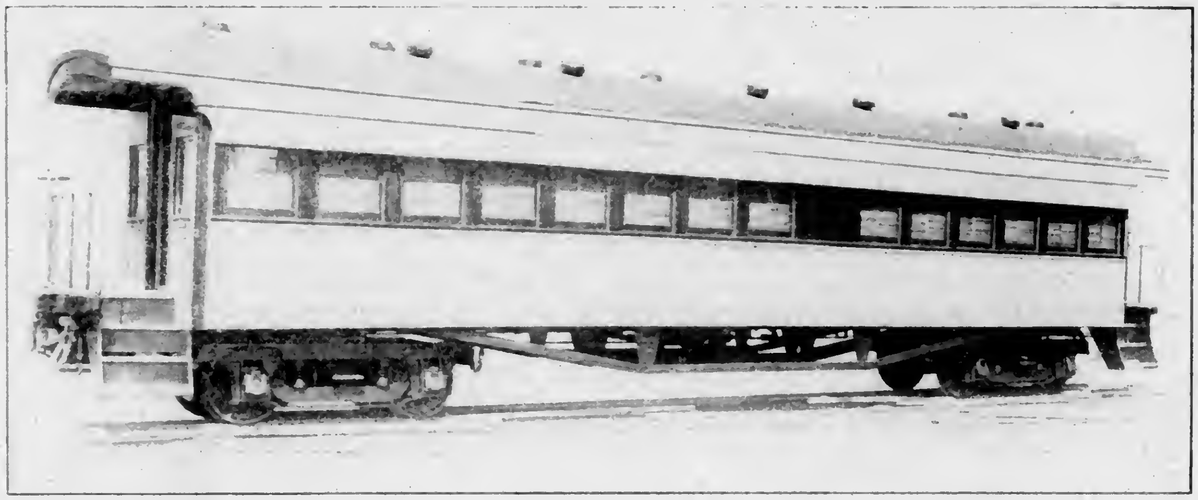
The dimensions of the second-class passenger and the combi-

INTERIOR OF SECOND-CLASS PASSENGER CAR, WITH THE ROOF ONLY PARTIALLY FINISHED, SHOWING THE HOLES THROUGH THE CARLINES FOR CIRCULATION OF AIR IN THE ROOF.



INTERIOR OF FIRST-CLASS PASSENGER CAR. THE ROOF IS SIMILAR TO THAT FOR THE SECOND-CLASS PASSENGER CAR, EXCEPT THAT THE INSIDE CONTOUR IS CHANGED TO GIVE A CLEAR-STORY EFFECT.

COMBINATION BAGGAGE AND SECOND-CLASS PASSENGER CAR—PHILIPPINE RAILWAY COMPANY.



FIRST-CLASS PASSENGER CAR—PHILIPPINE RAILWAY COMPANY.

PASSENGER CARS FOR THE PHILIPPINE RAILWAY.

About two years ago the Philippine Railway Company was granted a perpetual concession for building, equipping and operating between 300 and 400 miles, about equally divided between the islands of Cebu, Panay and Negros. The map shows the proposed routes, the dotted lines indicating mileage not finally located. On June 14, 1906, a party of fifty American engineers, organized by J. G. White & Co., constructing engineers for the railroad, landed in the Philippines. Previous to this time a thorough study of the resources and topography of the island had been made and tentative routes had been mapped out. The engineers divided into several parties and surveys on all three of the islands were pushed as rapidly as possible, so that by November nearly all the main surveys were completed and ground was broken on Cebu.

According to the concessionary contract sections of not less than twenty miles are to be put in operation as completed. Two sections are already in operation upon the island of Cebu and one on Panay. It is expected that the third section on Cebu will be placed in operation about May and the second section on Panay about August of this year. It was feared that it would be necessary to import Chinese labor for building these roads, but the contractors found that by paying a good wage, and furnishing the workmen with a scientifically proportioned diet of good nourishing food, splendid results could be obtained and a first-class lot of workmen are rapidly being developed.

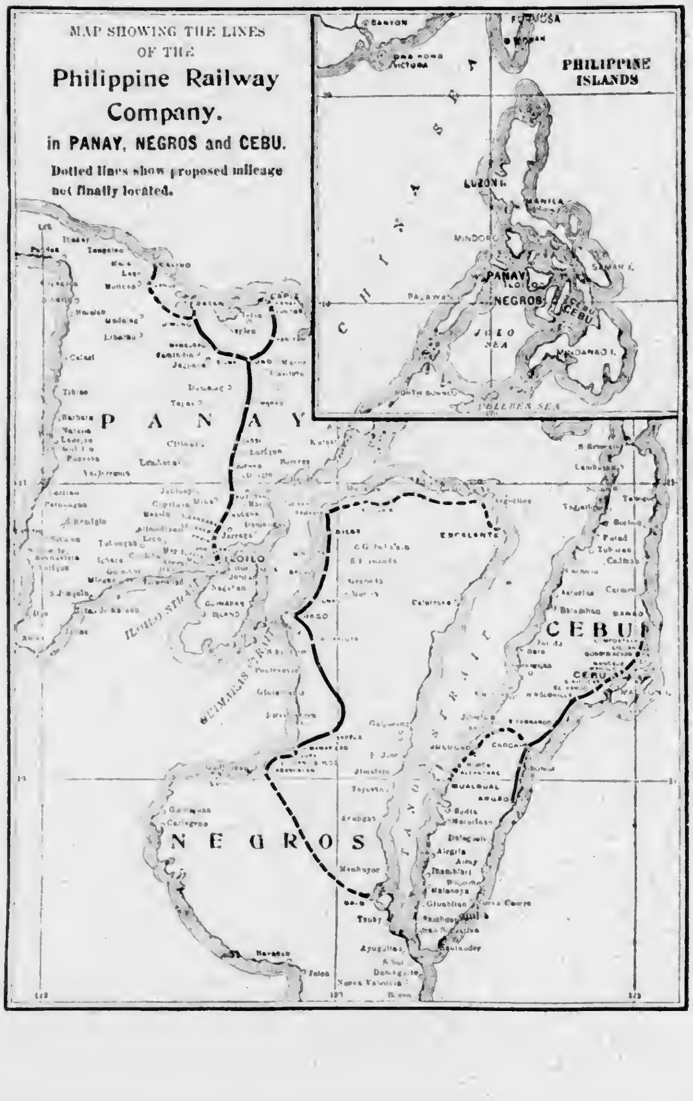
The original concession provided for a 3 foot 6 in. gage; other questions of construction, equipment and operation have been left to the directors of the company, the Technical Board, and the Philippine Commission. For the construction work four 50-ton mogul locomotives were ordered; also 3 light construction engines, fifty 40-ton flat cars and fifty Roger convertible ballast cars. The mogul locomotives have 17 x 24 in. cylinders, 50 inch drivers and a tractive effort of 21,000 lbs. High carbon native lignite coal is used as fuel; diamond stacks and spark arrestors are used to prevent the escape of sparks.

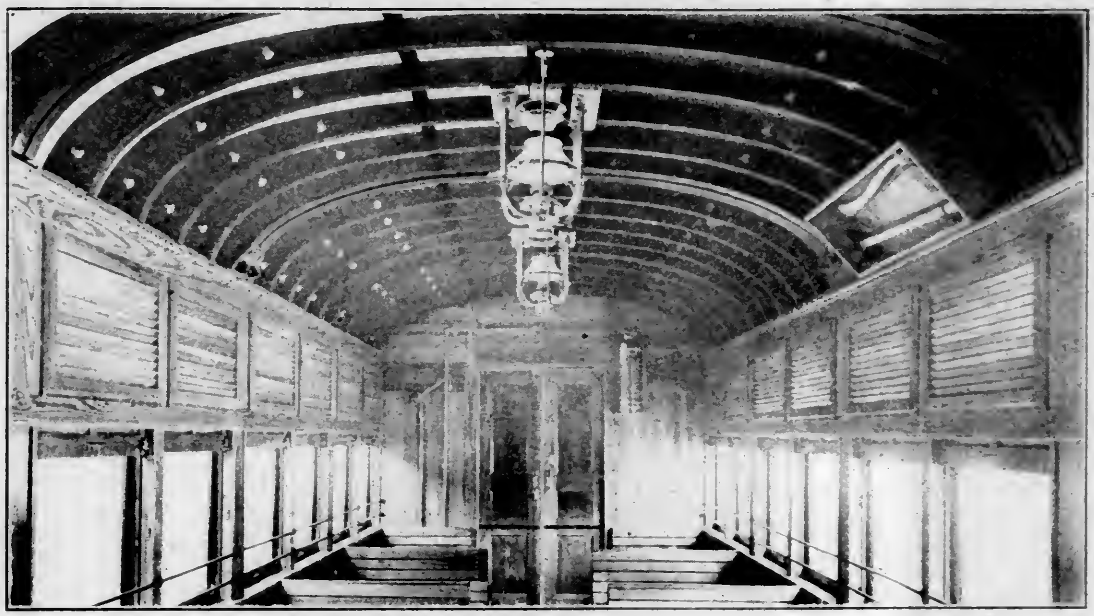
Recently six mogul locomotives were ordered; also four combination parlor and first-class cars, four combination baggage and second-class cars, fifteen second class cars, forty 10-ton and forty 20-ton box cars. These have been completed and are in transit; meanwhile but one train a day is operated in each direction, accommodations for passengers being provided by roofing over and building seats on the flat cars.

The cars were designed by G. R. Henderson, who acts in the dual capacity of consulting engineer for the railroad company and for the Philippine Commission. The passenger cars were built at the Wilmington, Del., plant of the American Car & Foundry Company. The designer was confronted with several peculiar problems. The construction must be as simple and substantial as possible, and such that what few repairs may be necessary can be made by unskilled labor. The cars must be suitable for a tropical climate and the design must be such that after being erected at the works they could be knocked down into convenient sections for shipment. The details of the different types of the passenger cars, as well as of the freight equipment, have been made interchangeable, as far as possible. The general dimensions of the combination parlor and first class passenger cars are as follows:

Length over body of car	13 ft. 1½ in.
Width over sun shades	9 ft. 6 in.
Inside length of car	12 ft. 3½ in.
Inside width of car	7 ft. 9¼ in.
Height from side sill to plate	6 ft. 9 in.
Length over underframing	43 ft.
Width over underframing	8 ft. 1½ in.
Distance between truck centers	32 ft. 6 in.
Height from rail to center of coupler	2 ft. 10 in.
Height from rail to top of platform	1 ft. 2 in.

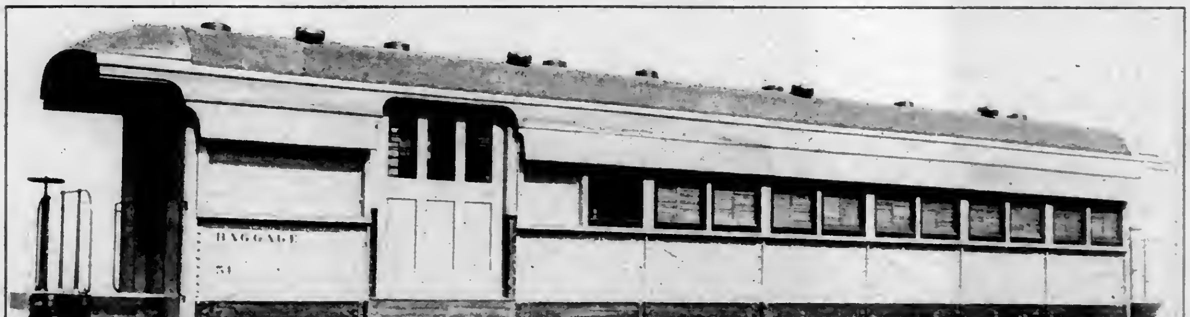
The dimensions of the second class passenger and the combi-





INTERIOR OF SECOND-CLASS PASSENGER CAR, WITH THE ROOF ONLY PARTIALLY FINISHED, SHOWING THE HOLES THROUGH THE CARLINES FOR CIRCULATION OF AIR IN THE ROOF.

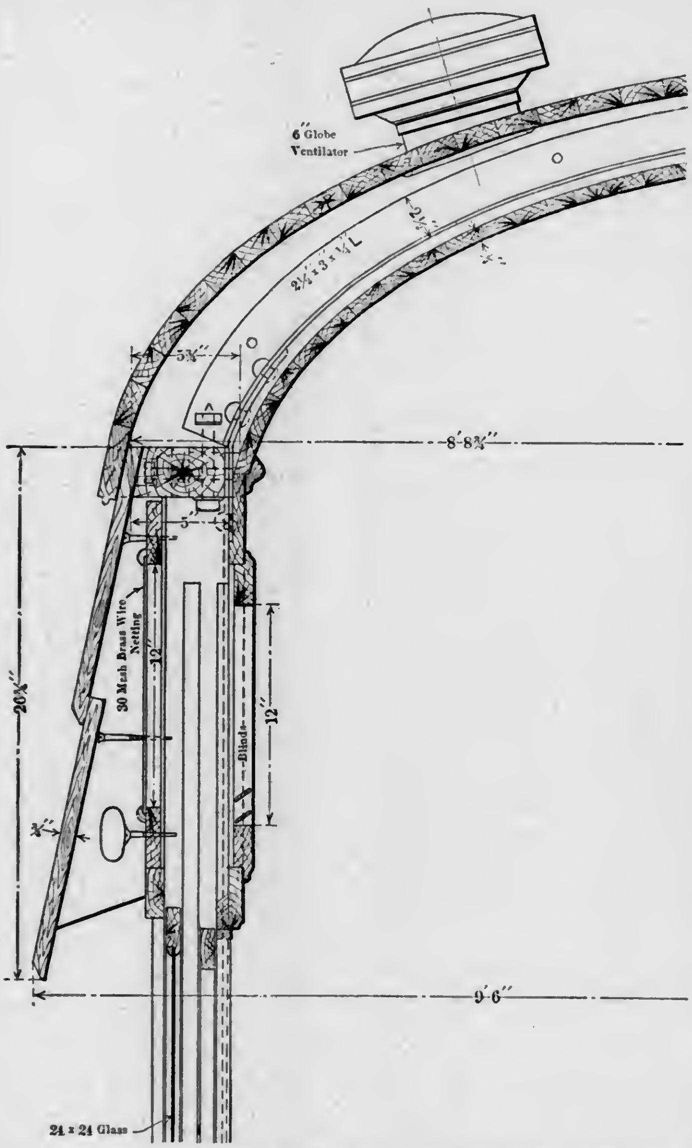
INTERIOR OF FIRST-CLASS PASSENGER CAR. THE ROOF IS SIMILAR TO THAT FOR THE SECOND-CLASS PASSENGER CAR, EXCEPT THAT THE INSIDE CONTOUR IS CHANGED TO GIVE A CLEAR-STORY EFFECT.



COMBINATION BAGGAGE AND SECOND-CLASS PASSENGER CAR—PHILIPPINE RAILWAY COMPANY.

nation baggage and second-class passenger cars are the same except that the inside length of these cars is 4 in. less and the inside width 1 in. less. The underframes of the different types of passenger equipment are interchangeable. They consist of standard shapes of open hearth steel, the center sills being 10 in. channels, weighing 15 lbs. per foot. These have a top cover plate extending from the end plates to the center of the car and are latticed underneath. The sills are spliced in the middle, so that the underframe can be shipped in two sections. The underframe is trussed by four steel angles, 4 x 3 x ⅜ in. with queen posts built of ¼ in. plates and 4½ x 2½ in. T's.

The bolsters have ⅜ x 18 in. top and ⅝ x 12½ in. bottom plates with a ⅜ in. web and steel connecting angles. The center sills at the bolster are securely tied by two channel sections connected to the sills by angles. The end sills are built up of Z-bars,



PARTIAL SECTION THROUGH THE ROOF AND THE SIDE ABOVE THE WINDOWS OF THE SECOND-CLASS PASSENGER CARS.

angles and plates. The steel platforms are of special design furnished by the Standard Coupler Company. The couplers have a side movement of 5 in. in either direction and are kept central by flat springs on each side. The uncoupling lever is operated from the ground by a 3/16 in. chain on the left side.

Yellow pine sills for supporting the floor are securely bolted to the side and center sills and also to cross channels. The flooring is of yellow pine 1¾ in. thick. The corner posts, door posts and lintels, are of ash; the side and end plates are of yellow pine bolted to T-iron posts and plates. The sun shades are of teak and will be furnished and applied in the Philippines. The sides of the cars were shipped in three sections each.

The roof is partly supported by 4½ x 2½ in., 8 lb. T's attached to the frame by gusset plates and braced by ¼ x 2½ in. iron straps, which run diagonally and are bolted to the siding. The carlines are of flat iron, 1½ x 2 in., except where the different sections of the roof are joined, in which case they are of angle iron. The roof is covered with yellow pine, 13/16 in. thick, and ceiled with yellow pine ¾ in. thick, leaving a considerable air space between, as shown on the drawing. The central ventilators extend through the roof and ceiling, but the side ventilators extend through the roof only. Reference to the detail drawing will show that the air may be drawn up underneath the sun shade, through the netting and the holes in the side plate and out through the side ventilators, or it may pass up underneath the sun shade, through the wire netting and the blinds into the car and out through the central ventilators. The carlines have holes in them, as shown on the photo of the interior of the second-class car, to assist in the circulation of the air in the roof.

Some idea of the interior finish of the cars may be gained from the accompanying photographs. The outside sheathing on the parlor cars is teak and is to be applied at the Philippines. The second-class cars do not differ greatly from the first-class cars except as regards the finish, no outside sheathing being applied to the second-class cars, and the interior finish being more simple and plain. The cars complete weight about 42,000 lbs.

The trucks are equipped with 4¼ x 8 in. journals and 30 in. wheels weighing 550 lbs. each. The side frames are steel angles, 6 x 4 x ½ in., connected by ¼ in. gusset plates with the 4 x 3 x ⅜ in. end angles. Eight-inch steel I-beams are used in both the transoms and bolsters. The spring plank is built up of angles and plates.

THE AUTOMOBILE INDUSTRY.—Statistics recently compiled by the Association of Licensed Automobile Manufacturers show that the total value of American made automobiles for 1907 was $105,669,572. This represents 52,302 cars manufactured during the year. Of these, all but 5,000 were gasoline vehicles, the smaller number being divided between steam and electric machines. In 1904 the value of the automobile output of the United States factories was $26,645,064, and a steady increase has been noticeable every year since. It is estimated that 58,000 employees were engaged last year in the various factories, while the capital employed was more than $94,000,000. As in many other manufacturing products, there is an indirect investment, which is closely allied to vehicle manufacture. This includes such products as tires, rims, lamps, speedometers, drop forgings, etc. Close estimation shows that there are 29,000 men employed in this indirect manufacture, with a total capital of $36,700,000. Unlike many other manufactured products, the sales end of the automobile industry is exceedingly expensive. At the close of the year 1907 there were 2151 sales and garage establishments employing 21,500 persons, with a capital of $57,500,000. Not including the manufacture of motor cycles or the sale of supplies and accessories, the total estimation is: Value of product sold, $105,669,572; total capital employed, $171,448,769; number of employees involved, 108,500.

DON'T DEPEND ALTOGETHER ON ENGINEMEN'S REPORTS.—What is needed most to make pooling a success is a determination on the part of the mechanical officers, from the superintendent of motive power down through the list in their order, to take care of the power regardless of whether the enginemen help any or not. Depending on such help and not getting it, is a poor excuse for not having the power in good serviceable condition. The better plan is to do all the work reported and all that appears necessary even though it is not reported. Every man in the official organization of a shop or round house should be ambitious and not a shirk. There is no room for the latter class of men in an up-to-date organization.—*Mr. D. R. MacBain before the Traveling Engineers' Association.*

Trade of the United States with its American neighbors in 1907 amounted to nearly $1,000,000,000, against a little more than a third as much a decade ago.

POWER REQUIREMENTS OF RAILROAD SHOP TOOLS.*

BY L. R. POMEROY.

Generally speaking, the generator capacity for railroad repair shops is equal to approximately 15 kw. per locomotive pit, or space in erecting shops occupied by one locomotive. This includes the requirements for tools, cranes, heating, blower and exhaust fans: *i.e.*, provides for all power required except that needed for lighting.

The tools alone require about 9 or 10 kw. per pit; the heating, and the blower and exhaust fans demand 5 kw. per pit, while 3 kw. per pit will care for the ordinary shop and adjacent yard lighting. If in addition to shop requirements, power is needed for lighting terminal yards, buildings, etc., an increase in generator capacity must be made to cover such demands.

The accompanying curves and tables are submitted to cover the horse power requirements of the machine tools generally found in railroad repair shops.

The extensive tests made by Dr. Nicholson of the Manchester Technical School, England, confirm the correctness of the foregoing formula, and form a very interesting contribution to the subject. A careful analysis of the results of these experiments shows the average horse power required at the motor, per pound of metal removed per minute, to be as follows:

Medium or soft steel or wrought iron	2.4 h.p.
Hard steel	2.65 h.p.
Cast iron, soft or medium	1.00 h.p.
Cast iron, hard	1.36 h.p.

Using the symbols of previous formula the horse power becomes:—

F × D × f.p.m. × 12 × N × W × K (2)†

where W equals the weight in pounds of a cubic inch of the metal, and K is the coefficient for that metal as given above. The value of W for the different metals is as follows:—

Cast iron	0.258
Wrought iron	0.278
Steel	0.284

The following examples illustrate the more or less heavy cuts to which reference has been made; the larger powers given are exceptional, while the average requirements are far below these,

BOLT AND NUT MACHINERY, HELVE HAMMERS, MULTIPLE DRILLS, ETC.

	Motor h.p. required to drive
1½" single head bolt cutter	1½
Pratt & Whitney No. 4 turret bolt cutter	2
2 spindle stay bolt cutter	2
1½" Acme double head bolt cutter	2½
1½-2½ Acme nut facer	2½
6 spindle nut tapper	3
1½" triple head bolt cutter	3
¾-2½" double head bolt cutter	3
2" triple head bolt cutter	5
4 spindle stay bolt cutter	5
Bradley hammer	7½
Niles 4 spindle multiple drill	7½

PUNCHES AND SHEARS.

	Motor h.p. required to drive
No. 4, 36" throat, L. & A. punch	3
No. 9 horizontal flange punch	5
No. 2 Hillis & Jones combination punch and shear	5
Alligator shear (stock 5" x 1")	5
Lenox rotary bevel shear	7½
36" multiple tank plate punch with spacing table	7½
No. 3 Hillis & Jones combination punch and shear, 12" throat	7½
No. 2 horizontal punch 20" throat	7½
No. 3 Hillis & Jones combination punch and shear, 36" throat	10
No. 3 angle shear 5" x 1" bar	10

SAWS.

	Motor h.p. required to drive
Band saw, 36" wheel	3
Band saw, 42" wheel	5
Swing cut off saw	5
Band saw, 48" wheel	7½
Greenlee 1½ self-feed rip saw	10
Greenlee vertical automatic cut off saw	15
40"-46" saws	15
Auto. band resaw	20
Greenlee No. 6 aut. cut off saw	20
Greenlee No. 3 rip saw	20
Woods No. 4 rip saw	20
Extra heavy aut. rip saw	25

GRINDERS.

	Motor h.p. required to drive
Air cock grinder	1
No. 3 Brown & Sharp universal grinder	3
Link grinder	3
Sellers universal grinder for tools	5
Norton 18" x 96" piston rod grinder	5

MILLERS.

	Motor h.p. required to drive
Vertical miller, Becker-Brainard No. 2	1
Valve miller No. 2	2
Universal miller No. 3, Brown & Sharp	2
Universal miller No. 4, Brown & Sharp	3
Universal No. 6, Becker-Brainard	5
Niles heavy vertical	10

WOOD WORKING TOOLS.

	Motor h.p. required to drive
Fay-Egan single spindle vertical boring machine	3
Fay-Egan 3 spindle vertical boring machine	4
Fay-Egan No. 6 vertical mortiser and borer	6
Fay-Egan No. 7 tenoner or gainer	7½
" universal wood worker	7½
" 4 spindle vertical borer	7½
" 5 spindle vertical borer	10
14" inside moulder	12
Fay-Egan universal tenoner and gainer	12
" vertical tenoner	12
Greenlee aut. vertical tenoner	15
Fay-Egan No. 3 gainer, also Greenlee	15½
Greenlee Ex. Range 5 spindle borer and mortiser	15
Greenlee vertical mortiser	15
Fay-Egan auto. gainer, also comb. gainer and mortiser	20
Fay-Egan No. 8 vertical saw and gainer	20½
Vertical hollow chisel mortiser and borer	20
Fay-Egan 14½" double cyl. surfacer	20½
Heavy outside moulder	20
6 roll D. C. planer and matcher	25
Double cylinder fast flooring machine	30
Double cylinder planer and matcher	30
Fay-Egan No. 8 auto. tenoner	30½
Woods No. 27 matcher	25
4 side timber planer, heavy	60

Occasionally certain tools are selected for the purpose of performing extra heavy service, to utilize the full capacity of the new rapid cutting tool steel, as is now done in manufacturing shops. In such cases the power to drive the machine must be figured on the basis of service required, but as these cases are few and exceptional, the curves will be found to meet the majority of conditions, and the exceptions can be taken care of by the following formula:

Horse power to drive = F × D × f.p.m. × 12 × N × C (1)

Where:—
- F = feed in inches
- D = depth of cut in inches
- f.p.m. = feet per minute
- N = number of tools cutting
- C = a constant with the following values, depending on the class of material:—

Cast iron	0.35 to 0.5
Soft steel or wrought iron	0.45 to 0.7
Locomotive driving wheel tires	0.70 to 1.00
Very hard steel, such as crucible steel driving wheel tires	1.00 to 1.10

This formula is based on Prof. Flather's dynamometer tests, which check up fairly well with actual motor tests, and it is therefore submitted with confidence.

As an example of its accuracy, the aggregate horse power of 45 tests made with various tools was 247.7, while the calculated aggregate horse power by formula equalled 247.2.

and all are submitted as actual cases which have come under the writer's observation:

(a) 100 inch driving wheel lathe—(material steel driving wheel tires) 5/16" feed, 5/16" cut, at 18.5 feet per minute—two tools cutting.
Substituting in formula (1) we have:—
5/16 × 5/16 × 18.5 × 12 × 2 × C = 40 h.p.
Same lathe, 3/16" feed, ¼" cut, at 16 f.p.m.—two tools cutting
3/16 × ¼ × 16 × 12 × 2 × C = 16 h.p.

(b) Old 76 inch driving wheel lathe, (material driving wheel tires)
1/16 × 1/4 × 16 × 12 × 2 × C = 5 h.p.

(c) Steel tired wheel lathe (material engine truck wheels)
1/7 × 5/16 × 16 × 12 × 2 × C = 17 h.p.

(d) Planer (material cast iron)
5/32" × 3/8" × 16' × 12 × 0.35 (one tool cutting) ...... 4.5 h.p.
(two tools cutting) ...... 9 h. p.

(e) Planer (material wrought iron engine frame)
5/32" × 1/2" × 16' × 12 × 2 × 0.5 (two tools cutting) ... 15 h.p.

(f) 76 inch boring mill (on cast steel driving wheel centers)
1/8" × 3/4" × 30' × 12 × 3 × 0.45 (three tools cutting) .. 45 h.p.
Same machine boring driving wheel tire
1/8" × 3/16" × 28' × 12 × 2 × 1 (two tools cutting) .... 15 h.p.

(g) 84 inch boring mill (on 62" cast iron wheel centers)
1/8" × 1/10" × 30' × 12 × 3 × 0.35 (three tools cutting) 4.7 h.p.
Same mill boring 44" steel tire
1/4" × 3/32" × 26' × 12 × 2 × 1 (two tools cutting) ... 14.5 h.p.

(h) The following is a special test on an extra heavy driving wheel lathe, and gives results representing unusual conditions. The operator was given a heavy bonus to develop the ultimate capacity of the machine.
Average feed 0.4625", depth 0.0423", at 12.2 f.p.m. (two tools cutting).

These figures are the averages of 37 tests, and represent a consumption of 46 h.p., while the maximum h.p. required was about 65. The machine was equipped with a 40 h.p. direct current motor with 2.1 speed variation.

* From the October, 1907, issue of the *General Electric Review*.

† W × K in formula (2) = C in formula (1). For cast iron W × K = .258 × 1.00, or 1.36 = .258, or .35. For wrought iron W × K = .278 × 2.4 = .667. For hard steel W × K = .284 × 2.65 = .75.

The lathe in question was a "special," extra heavy, and of about double the capacity and cost of the standard driving wheel lathe of equivalent size. On average work, the same investment if expended on two lathes will turn out more work in a year than this special machine.

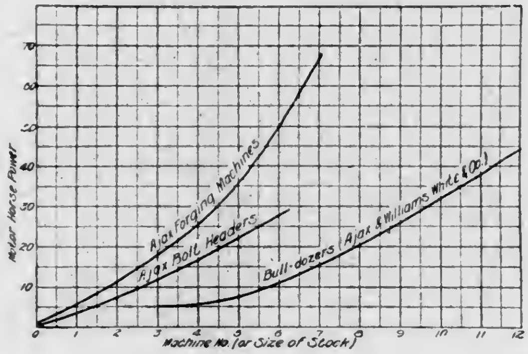
For rapid estimates, where the foregoing data is not available, the horse power required can be obtained by the following formulæ:

$$\text{(Single belt) horse power} = \frac{d \times f \times \text{r.p.m.}}{12 \times 400} \qquad (3)$$

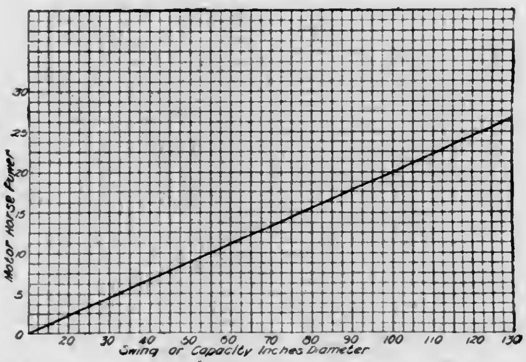
$$\text{(Double belt) horse power} = \frac{d \times f \times \text{r.p.m.}}{12 \times 400 \times 0.7} \qquad (4)$$

where:
d = diameter of smaller pulley in inches
f = face of pulley in inches
r.p.m = revolutions per minute.

These formulæ are very conservative and provide for about as much overload capacity for belts as is ordinarily assumed for motors; they also provide a liberal allowance for the influence of centrifugal force, and for the diminishing arc of contact on the pulley, when it is driven from a larger one. They are espe-



FORGING AND BOLT HEADING MACHINES.



BORING MILL—ONE TOOL CUTTING 20 FT. PER MIN.

cially useful in figuring the power required for wood working machines and were arrived at largely from experience with such apparatus.

Another formula, adapted from Ruleaux, giving somewhat higher values, is preferred by some, as it considers the thickness of the belt. In this case the allowance for centrifugal force and for the arc of contact, being less than 180 degrees, is taken care of in the selection of values for the constant C:

$$\text{Horse power} = t \times w \times \text{f.p.m.} \times C, \qquad (5)$$

or if the r.p.m. and not the f.p.m. is known:

$$\text{horse power} = \frac{t \times w \times d \times \text{r.p.m.} \times C}{4}$$

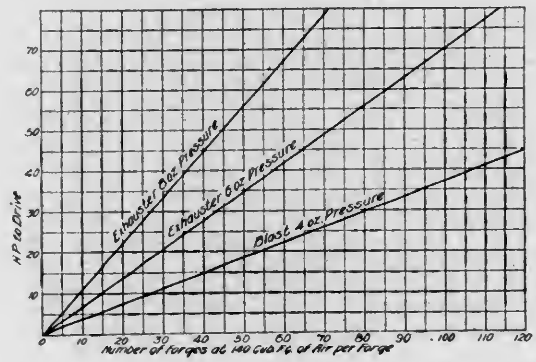
where:
t = thickness of belt in inches
w = width of belt in inches
d = diameter of pulley in inches
C = a constant, of following values:

Leather belt	0.0062 to 0.0098
Cotton belt	0.0036 to 0.0068
Rubber belt	0.0050 to 0.0082

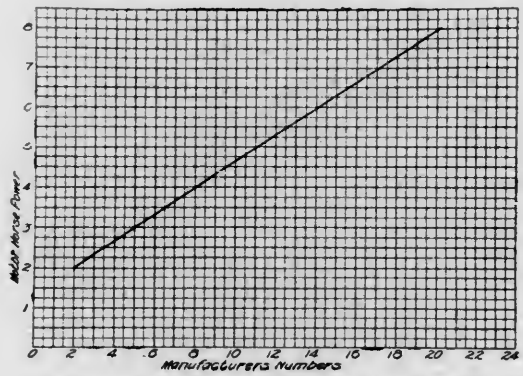
The tool builders do not always discriminate between the requirements of manufacturing plants and those of railroad repair shops, and for this reason motors are often recommended that are larger than necessary. For example: the *finished* product of the axle departments of such concerns as the United States Steel, Midvale, Bethlehem, and Cambria Companies, becomes the *raw* material for railroad shops. In the former shops the forging is turned out from the hammer without much regard to finished dimensions, as it is much cheaper to rough out to size on special rapid reduction lathes than to attempt to reduce to size under the hammer.

For such machining high power is required, but for the same lathes in railroad shops, where the work performed is mainly finishing cuts on journals and wheel seats, a smaller and cheaper motor may be selected.

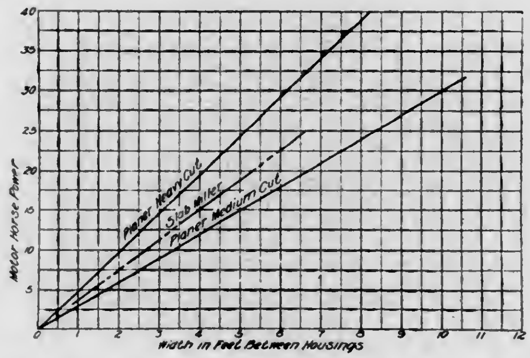
The Bement-Niles lathe which was furnished the Howard Axle Works may be given as an example of extreme requirements, such as mentioned. The capacity of this machine is two



FANS.



PIPE THREADING AND CUTTING MACHINES.



PLANERS (TWO TOOLS 15 TO 20 FT. PER MIN.). RATIO OF CUT TO RETURN 1 : 3.

cuts, each 5/8 inch by 1/8 inch at 60 feet per minute, and at this rate of cutting the machine will require a 60 horse power motor.

Another machine, built for the same class of work and used largely in axle shops and in many railroad shops, is capable of taking two cuts of 3/4 x 1/12 inch, at 24 feet per minute. This requires 18 h.p. and the machine is usually furnished with a 20 h.p. motor. While this power is all right for the full capacity of the machine, 10 h.p. will cover the requirements of the same tool on average railroad shop work.

The number of pits required in a locomotive erecting shop =

$$\frac{\text{(Total number of engines)} \times \text{(average number of days in shop)}}{300 \text{ [number of working days in year]}}$$

Example:—400 engines; average days in shop, 25.

$$\text{Number of pits} = \frac{400 \times 25}{300} = 33.$$

$$\text{Capacity per year} = \frac{(\text{Number of pits}) \times 300}{\text{Average number of days in shop.}}$$

In order to reduce to about 20 the average number of days in the shop that are required for general overhauling, it is estimated that the machine shop adjacent to the erecting shop should contain seven machine tools per engine pit, and the floor area in order to accommodate seven tools per engine capacity should be about 1500 square feet per pit.

Power required for air compressors equals the delivery of free air in cubic feet per minute, at 100 lbs. pressure of the compressor, multiplied by 0.14.

Modern erecting and machine shops, including heating, cranes, etc., cost from \$2.50 to \$3.50 per square foot of inside measurement

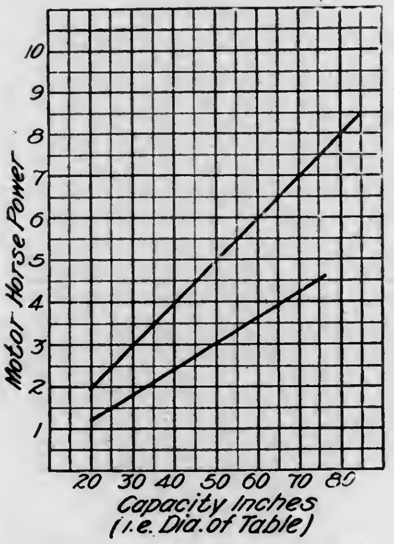
$$\text{Rate per kw. hour to cover fixed charges} = \frac{\text{total fixed charges per year}}{(\text{max. demand}) \times 8760 \times (\text{load factor})}$$

Illustration:

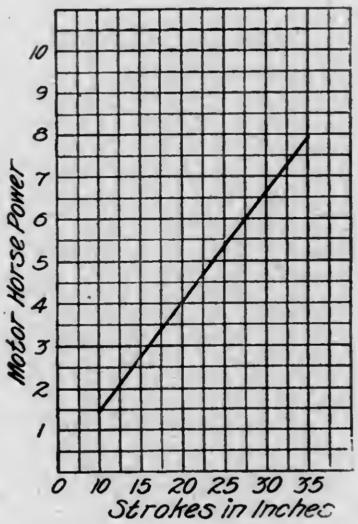
Fixed charges	\$8330.00
Maximum demand	500 kw.
Load factor	33 per cent.

Then:

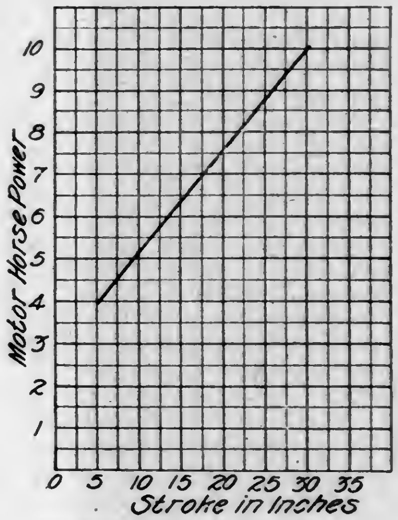
$$\text{rate} = \frac{\$8330}{500 \times 8760 \times .33} = 0.0057$$



DRILL PRESS, 15 TO 20 FT. PER MIN.



SHAPER, 15 TO 20 FT. PER MIN.



SLOTTER, 15 TO 20 FT. PER MIN.

RESULTS OF THE ELECTRIFICATION OF THE NEW YORK CENTRAL & HUDSON RIVER RAILROAD.*

William J. Wilgus.

Initial Zone Operation.—As previously stated, the company was forced to confine temporarily the change of motive power to the operation of the suburban zone terminating at High Bridge, 7 miles out; and at Wakefield, 13 miles from the terminal. This postpones for two or three years the extension of electrical service to the northerly termini of the suburban zone. In the meantime, the power on through trains is changed at the temporary termini. At the same points, multiple-unit trains north-bound have steam locomotives attached and thence proceed as non-electric trains; and south-bound the steam locomotives are detached and the trains continue by electricity without locomotives. The average time required for making the changes, including that lost in slowing down and regaining speed is as follows:

Through trains with locomotives	4½ min.
Multiple-unit trains, north-bound	3 "
Multiple-unit trains, south-bound	2½ "

On the Hudson Division this delay has been largely compensated by shortening the line at Marble Hill and the elimination of the grade track crossing at Spuyten Duyvil.

Results.

Expectations from Electrification.—Now that the change of motive power in the initial electric zone has been completed for sufficient time to gain at least a preliminary idea of the results, the question naturally arises, with what success has the change met expectations?

It has already been explained that the principal reasons for undertaking the work were twofold:

(1).—Demand of the public for the abolition of the nuisances incident to the use of steam locomotives south of the Harlem River; and

(2).—Need for increased capacity of the terminal, by the elimination of a large proportion of the switching movements required with steam locomotive practice; and relief to the main line entrance to the terminal by reducing its use for haulage of dead locomotives and cars to Mott Haven.

As secondary considerations there were:

(3).—The possibility of sufficient economy in operation at least to offset largely the additional fixed charges on the cost of the electrical installation; and

(4).—Opportunities for an ultimate large increase in traffic and corresponding growth of revenue to justify the expenditure for all improvements within the suburban zone.

What do the observations made thus far disclose?

The first two expectations have been completely realized.

Park Avenue Tunnel.—The atmospheric conditions in the Park Avenue Tunnel show marked improvement, even with the presence of the remaining New Haven Company's steam service.

Increased Terminal Capacity.—The effect on the operating efficiency of the terminal has been very gratifying, the increased capacity being estimated at one-third. There has also been a large reduction in the number of shop or "dead" trains to and from Mott Haven.

Reduced Cost of Operation.—The results, as regards the third expectation, have been most surprising. The operation, for a considerable period, of steam and electric equipment side by side has afforded an unexampled opportunity for a true comparison of costs of operation. Until now, data on this subject have been based on theory, ignoring many of the indeterminate features of actual operation that have such a weighty effect on costs. For instance, among the variables entering into an analysis of this character are:

(a).—Cost and quantity of coal and water at the power station, and on the steam locomotive tender;

(b).—Relation of ton-mileage of the motive power to total ton-mileage, including motive power and cars;

(c).—Frequency and volume of traffic;

* From a paper on "The Electrification of the Suburban Zone of the New York Central & Hudson River Railroad in the Vicinity of New York City," presented at the March 18, 1908, meeting of the American Society of Civil Engineers, see page 68, Number 2, Volume XXXIV, of the *Proceedings*. The paper is very extensive and complete. It considers the reasons for the electrification of the New York Central; also the reasons for the adaption of direct-current and other important features. It discusses at length the general features of construction and equipment and closes with the section on "Results."

TABLE 1.—COMPARISON OF COSTS PER DAY OF AVAILABLE SERVICE OF STEAM AND ELECTRIC LOCOMOTIVES FOR INTEREST, DEPRECIATION, REPAIRS, INSPECTION, AND HANDLING.

SUBJECT.	STEAM.				ELECTRIC.			
	Description.	Amount per annum.		Per day.	Description.	Amount per annum.		Per day.
Interest	4¼% on $15 000		$637.50		4¼% on $30 000		$1 275	
Depreciation	5% on $15 000		750.00		5% on $30 000		1 500	
Repairs	General at West Albany	$1 170			General at Harmon	$468		
	Running at Mott Haven	414			Running at High Bridge and Wakefield.	166		
	Trips to shops, 300 miles	168			Trips to shops. 60 miles	34		
	Use of shops	90	1 842.00		Use of shops	36	704	
	Total for 335 days available for service.		$3 229.50	$9.64	Total for 350 days available for service.		$3 479	$9.94
Handling and inspection, including fixed charges and maintenance of land and structures	Mott Haven engine-house plant, 365 days		1 231.00	3.37	High Bridge and Wakefield inspection sheds, 365 days		200	0.55
Total			$4 460.50	$13.01			$3 679	$10.49

The saving in favor of the electric locomotive, therefore, is $2.52 per day, equal to 19 per cent.

(d).—Mechanical and electrical design of motive power as affecting repairs, and hours available for active service;

(e).—Fixed charges, depreciation, and maintenance on all items of both kinds of service, that have a bearing on comparative results, including land, structures, and equipment.

In other words, to obtain a true comparison, observations must be made under like conditions in a known service.

With this object in view, a typical steam switching locomotive,* engaged in terminal service, and a steam passenger locomotive,† assigned to road service, were each selected for observation in the same class of traffic with electric locomotives.‡ The terminal service embraced switching at the Grand Central yard, and hauling dead cars to and from Mott Haven storage yard, a distance of 6 miles. The road service comprised the hauling of schedule trains by the electric locomotive between the Grand Central Terminal and Wakefield, 12½ miles; and the same trains by steam between Wakefield and North White Plains, 11½ miles.

Observers constantly rode the locomotives for the period of the tests, namely, September 12th to 27th, 1907, in terminal service, and October 4th to 18th, 1907, in road service. Cyclometers and wattmeters registered actual distances, speeds, and current consumption. Record was also kept of the number of cars switched and hauled, and the proportion of time each day engaged in actual service, awaiting duty, and laid up for inspection and repairs.

The coal used contained 14,000 B. T. U. per lb., and the cost, per ton of 2,240 lb., was:

Steam locomotive in terminal service (anthracite)	$5.00 per ton.
Steam locomotive in road service (bituminous)	3.50 " "
Port Morris power station (bituminous)	3.05 " "
Water, per 1,000 gal., cost as follows:	
Terminal service and at power station	13 1/3 cents
Road service	5 "

The cost of electric current, when the power station designed load is attained, is taken at 2.6 cents per kw.-hr., delivered at the contact shoes of the equipment, and includes all operating and maintenance costs, interest on the electrical investment required to produce and deliver the current, depreciation, taxes, insurance, and transmission losses. The details of this cost are:

Items.	Operating costs.	Fixed charges.	Total.
Power station	$0.58	$0.44	$1.02
Transmission losses	0.19	0.15	0.34
Distributing system and sub-stations	0.32	0.92	1,24
Totals	$1.09	$1.51	$2.60

Locomotive wages are practically identical for each class of service.

* Six wheel; wheel base 11 ft. 6 in.; weight on drivers, working order, 152,500 lbs.; weight of 4,500 gal. tender, 89,500 lbs.; weight of 5,100 gal. tender, 91,500 lbs.

† Ten wheel; rigid wheel base 15 ft. 10 in.; wheel base of engine, 26 ft. 10½ in.; weight on drivers, working order, 156,000 lbs.; weight on truck, 46,500 lbs.; weight of tender loaded, 148,000 lbs.

‡ See AMERICAN ENGINEER, Jan., 1907, page 1. Rigid wheel base, 13 ft.; total wheel base, 27 ft.; total weight, 189,000 lbs.; weight on drivers, 137,000 lbs.; normal capacity of each locomotive, 2,200 h. p.; overload capacity, 3,300 h. p.

Table 1 shows the details of locomotive repairs, maintenance, and fixed charges for each class of service, from which it will be noted that, although the fixed charges and depreciation of the electric locomotive are higher than those of the steam, owing to the greater first cost, the net result is in favor of the electric locomotive, due to lower costs for repairs and maintenance. These results are based on actual observations of the steam locomotive covering a period of several years; and of the electric locomotive for two years on the experimental track near Schenectady and one year in the New York zone. The reasons for the lower cost of repairs on the electric machine are the simplicity of construction and the minimum number of mechanical parts. It is also worthy of comment that the electric locomotive costs very much less per day for repairs and maintenance, due to lower expenses for land and structures and fewer days out of service. For instance, the fixed charges and cost of maintenance and operation of the extensive steam engine plant on costly land, are comparable with the simple inspection-shed charges of the electric locomotive. The Schenectady experiments indicated that the cost of repairs of the electric locomotive of this type is about two-fifths of that of the steam locomotive of a corresponding age and capacity.

The results of these observations are summarized in Table 3. They show that, under the stated conditions, the electric locomotive has the following advantages over its steam rival:

- 19% saving in locomotive repairs and fixed charges.
- 18% saving in dead time for repairs and inspection.
- 25% greater daily ton-mileage.
- 6% saving in locomotive ton-mileage in hauling service.
- 11% saving in locomotive ton-mileage in switching service.
- 16% saving in locomotive ton-mileage in road service.
- 12% net saving in cost in hauling service.
- 21% net saving in cost in switching service.
- 27% net saving in cost in road service.

Even better results may be expected during winter months, when steam locomotives are subjected to many conditions that cause additional expenses not incident to the electric locomotive.

Reduced Cost of Grand Central Terminal Operation.—Owing to the partial use of steam switching locomotives, and the presence of the New Haven Company's steam road locomotives at the terminal, the full benefits of change of motive power have not yet been secured. However, on the same wage basis for 1907 as for 1906, the month of August, 1907, showed a decrease in cost of terminal locomotive and yard operation of nearly $3,000, although the number of cars in and out increased from 64,984 to 68,519. In other words, the cost of operation decreased 9 per cent. while the work done increased 5½ per cent., which is equivalent to a net saving of 13½ per cent.

Increased Revenue.—As to the fourth expectation—increased revenue from a larger volume of business—no definite conclusions can be reached until the extension of electrical service and the completion of the various other improvements afford an opportunity for increase in frequency and speed of train service; for the production of revenue from various sources at the terminal; and for the expansion of business that is sure to follow

TABLE 3.—SUMMARY OF COMPARATIVE TESTS OF STEAM AND ELECTRIC LOCOMOTIVES.

Kind of locomotive.	Miles per day.	Cars per day.	Busy hours per day.	Hours ready for duty daily.	Percentage of time dead.	Total ton-miles daily.	Car ton-miles daily.	Percentage of car ton-miles to total.	Car ton-miles per busy hour.	Coal or current per car ton-mile.	Total cost per car, in cents.	Speed and stops. Average miles per hour.	Maximum miles per hour.	Stops.	Cost per 1 000 car ton-miles. Supplies.	Wages.	Interest, depreciation, and repairs on locomotives.	Total.	Watt-hours required to do work of 1 lb. coal.
SWITCHING SERVICE—GRAND CENTRAL TERMINAL.†																			
Steam	10.91	55	† 1.83	† 6.16	† 0.52	2 580	916	0.35	501	3.36 lb. coal.	35.2	....	....	....	$8.06	$5.34	$7.61	$21.01	
Electric	11.13	53	† 2.01	† 6.80	† 0.26	1 980	914	0 46	445	264 watt-hr.	28.5	....	....	....	6.88	5.25	4.40	16.53	79
Advantages in favor of electric locomotives	0.22	....	† 0.18	† 0.64	† 0.26	......	......	0.11	....	....	6 7	....	....	....	1.18	0.09	3.21	4.48	
HAULING TO AND FROM MOTT HAVEN.†																			
Steam	40.0	45	† 3.36	† 5 18	† 0 53	16 540	11 720	0.71	3 490	0.46 lb. coal	51.6	11 9	48	0.9	1.12	0.35	0 52	1.99	
Electric	78.1	95	† 6.41	† 10.42	† 0.30	30 370	23 310	0 77	3 640	44.3 watt-hr.	43.2	12.3	45	2.0	1.16	0.31	0.28	1.75	96
Advantages in favor of electric locomotives.	38.4	50	† 3.05	† 5.24	† 0.23	13 830	11 590	0.06	150	....	8.4	0.4	3	1.1	......	......	0.24	0.24	
ROAD SERVICE.*																			
Steam	74.04	28	3.72	‡ 11.11	‡ 0.54	25 620	12 660	0 49	3 400	1.22 lb. coal	126.0	19.9	60	8.6	2 03	0 28	0.46	2.77	
Electric	126.22	43	5.34	‡ 13.70	‡ 0.43	33 210	21 510	0 65	4 030	52.3 watt hr.	100.0	23 6	55	2.9	1 37	0.31	0 34	2.02	43
Advantages in favor of electric locomotives.	52.18	15	1.62	‡ 2.59	‡ 0 09	7 590	8 850	0.16	630	....	26 0	3.7	5	....	0·66	.....	0 12	0.75	

* Portion of time of locomotives engaged in other service not shown in this table † Switching and hauling done by same locomotives.
Total time of locomotives in all classes of service.

the enlargement of the facilities of the company throughout the suburban zone, not only as regards the local service, but in an even larger degree from long-haul freight and passenger traffic.

Summary of Results.—To summarize, the observations thus far made demonstrate that this pioneer electric installation in heavy-traction trunk-line work in the United States has fully accomplished the purposes that prompted its adoption, namely:

(1).—Abolition of nuisances incident to the steam locomotive; and

(2).—Increased capacity of the Grand Central Terminal, a full year in advance of the date fixed by law; and in addition:

(3).—The promise, with the completion of the changes, of a saving, in cost of operation, of from 12 to 27 per cent., after providing for increased capital charges for electrification; and

(4).—The outlook of a large future growth of remunerative traffic, and other sources of revenue attendant on the use of electricity, much more than sufficient to provide for the increased capital charges for the other improvements.

Several years will be consumed in the gradual rounding out of the work as a whole; but it is gratifying to have this early indication of the success of the undertaking from both the engineering and financial standpoints.

Other Operating Conclusions.—Apart from these results, it is interesting to note the conclusions, suited to this particular problem, that may be drawn from a study of the various observations.

Equipment designed for the electric system over which it is to operate offers economies so superior as to overshadow any other advantages that may be claimed for a kind of equipment that can be operated over several systems.

In switching service, the economy of electric traction lies in savings for supplies, and in lower unit fixed charges and repairs due to less lost time for repairs and care.

In slow-speed hauling, the advantage lies in the lower unit fixed charges and repairs of the electric locomotive, due to its ability to do more work while busy, and to less lost time for repairs and care.

High-speed road service shows advantages for electric traction in all three items: supplies, wages, and fixed charges and repairs. The small 18 per cent. increase in current consumption for the greater speed of road service, as compared with hauling service, is in marked contrast to the 165 per cent. increase in coal consumption for steam traction.

Opportunities for large economies lie in the thorough training of motormen in the manipulation of their controllers, a very simple problem as compared with the difficulties of teaching both the enginemen and firemen on steam locomotives to perform their duties so as to result in fuel economy.

Maintenance of Track and Structures.—It is yet too early to express in dollars the comparative effect of steam and electric traction on the cost of maintaining and renewing tracks and structures. Repeated systematic inquiries of all foremen in charge of electric zone track maintenance, and of the motormen operating electrical equipment, have brought out the practically unanimous opinion that the effect of electric locomotives, apart from slightly greater wear on switches, does not differ from steam motive power, on either line or surface of tracks, but that the former has better riding qualities. The superiority of electric traction is manifest, of course, in the cessation of costly corrosive action of locomotive gas on metallic structures, and the freedom from cinders which, with the steam locomotive, cause heavy maintenance costs for cleaning, rock ballast, and pointing brick tunnel arches.

CONSERVATION OF THE NATION'S FUEL SUPPLY.—At a meeting held Tuesday, April 14, under the auspices of the American Society of Mechanical Engineers, Dr. W. F. M. Goss, Dean of the College of Engineering, University of Illinois, spoke upon the conservation of the nation's fuel supply, saying that economy in its production and use is to be enforced by a four-fold process. The necessary steps are: Scientific research for the establishment of facts; practical demonstrations of facts thus developed on a scale which will convince men that there is profit, direct or indirect, in a better practice; restrictive legislation which will protect the public from the competition of unscrupulous men; and finally effective inspection which will secure an enforcement of law. The process cannot successfully begin with coercion; it must begin with education.

SAFETY DEVICES EXPOSITION.—The second international exposition of safety devices was opened on April 13, at 231 W. 39th street, New York, and will continue until June 1.

TEN-WHEEL PASSENGER LOCOMOTIVE—ST. LOUIS & SAN FRANCISCO RAILROAD.

TEN WHEEL PASSENGER LOCOMOTIVE.

ST. LOUIS & SAN FRANCISCO RAILROAD.

The Baldwin Locomotive Works has recently delivered to the St. Louis & San Francisco Railroad ten passenger locomotives of the ten-wheel type, which are among the heaviest engines of this class ever built by that company.

About a year ago there appeared in these columns (Page 104, 1907), a description of some locomotives of the same type for passenger service, built for this railroad by the American Locomotive Company, which weighed 183,000 lbs. total and had 21 x 26 in. cylinders. They were equipped with Walschaert valve gear and an extended wagon top type of boiler, having a total heating surface of 2,654 sq. ft. The locomotives in this later order are considerably larger and more powerful and exceed the earlier ones in every dimension except grate area. The boiler is 68 in. diameter at the front ring as compared with 66⅜ in.; there are 364 2-in. tubes in place of 318; the cylinders are 23 x 26 in.; the weight has been increased to 194,450 lbs., of which 141,050 is on drivers, and the tractive effort delivered with the same steam pressure is 33,900 instead of 28,300. A comparison of the ratios between these two designs will show that the increased power is based on the increased amount of heating surface backed up with probably a somewhat higher rate of combustion on the grates.

The accompanying table will permit an easy comparison of this design with several other recent engines of this type and in-

Road	S. P.	T. & P.	Frisco.	N. Y. C.	C.&N.W.
Total weight	203,050	197,000	194,450	194,500	179,500
Weight drivers	159,750	165,000	141,050	148,000	135,500
Tractive effort	34,740	38,400	33,900	31,000	30,900
Wgt. driv. ÷ total wgt. %	78.5	83.5	72.5	76.	75.3
Wgt. per driving axle	53,250	55,000	47,017	49,333	45,167
Cylinders	22 × 28	22 × 28	23 × 26	22 × 26	21 × 26
Diam. drivers	63	63	69	69	63
Steam pressure	190	210	200	200	200
Total heating surface	2,994	2,931	3,039	3,327	2,959
Tube heating surface	2,788	2,731	2,867	3,124	2,808
Total heat. surf. ÷ vol. cyl	243	236	243	292	285
B. D. ratio	730	825	770	642	655
Reference in AMER. ENG.	p. 480–07	p. 77–08	....	p. 59–06	p. 247–07

dicates that this power, while primarily designed for passenger service, will also be found to be very satisfactory for fast freight service.

The most interesting feature of this design is found in the arrangement of the Walschaert valve gear, which, as do all the later designs, shows much improvement over the earlier arrangements. The most striking feature is the placing of the combination lever behind the guide yoke with the union link extending back from the cross head, and the employment of a very long valve stem, having a guide and bearing bolted to the guide yoke. This shortens up the radius bar considerably and permits the locating of the link somewhat further back than has been the previous custom with ten-wheel engines. This location in turn reduces the size and weight of the link support, which is fastened to the frame cross tie. It also compels the use of a short eccentric rod, the errors of angularity being largely overcome in this case by a long extension on the link. The reverse shaft bearing and link bearing are both incorporated in one casting bolted to the frame cross tie, the simplicity and lightness of which are shown in the detail illustration. This arrangement of the gear permits the use of the simpler design of guide yoke and allows it to be located much nearer the back ends of the guides.

The relief valve, noticed on top of the valve chest, consists simply of a plate resting on top of a horizontal seat and normally covering openings leading to the live steam ports. When the throttle is opened this plate is held down by boiler pressure acting on its upper surface. Excessive pressure within the cylinders, which acts upon a smaller area than the boiler pressure above, lifts this plate from its seat and opens communication between the two live steam ports.

The general dimensions, weights and ratios of these locomotives are as follows:

GENERAL DATA.

Gauge	4 ft. 8½ in.
Service	Passenger
Fuel	Bit. Coal
Tractive effort	33,900 lbs.
Weight in working order	194,450 lbs.
Weight on drivers	141,050 lbs.
Weight on leading truck	53,400 lbs.
Weight of engine and tender in working order	315,000 lbs.
Wheel base, driving	15 ft. 10 in.
Wheel base, total	26 ft. 10 in.
Wheel base, engine and tender	57 ft. 10 in.

RATIOS.

Weight on drivers ÷ tractive effort	4.16
Total weight ÷ tractive effort	5.72
Tractive effort x diam. drivers ÷ heating surface	770.00
Total heating surface ÷ grate area	64.00
Firebox heating surface ÷ total heating surface, per cent	5.65
Weight on drivers ÷ total heating surface	46.50
Total weight ÷ total heating surface	63.50
Volume both cylinders, cu. ft	12.50
Total heating surface ÷ vol. cylinders	243.00
Grate area ÷ vol. cylinders	3.79

CYLINDERS.

Kind	Simple
Diameter and stroke	23 x 26 in.

VALVES.

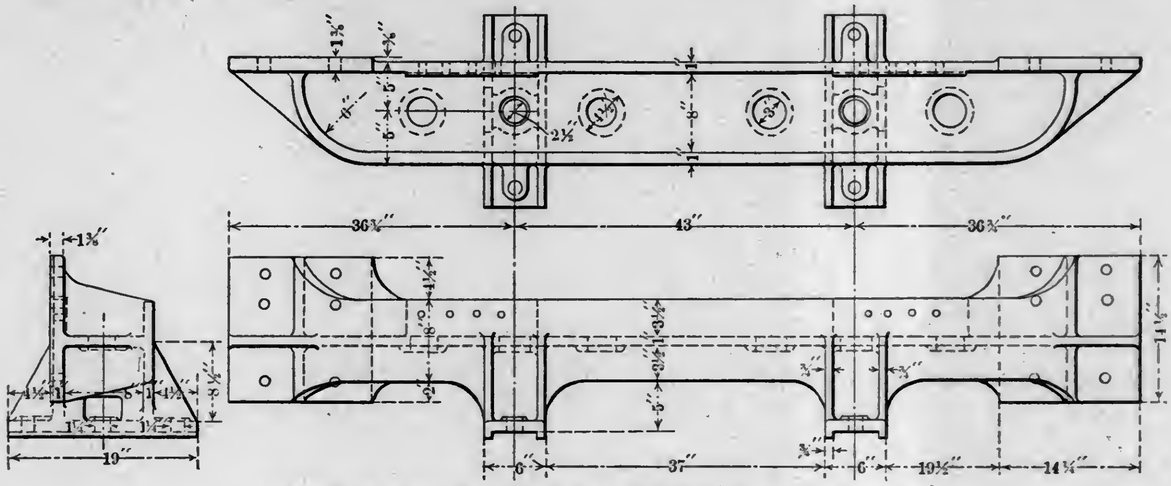
Kind	Piston
Diameter	13 in.
Greatest travel	6 in.
Outside lap	1 in.
Inside clearance	⅛ in.
Lead, constant	¼ in.

WHEELS.

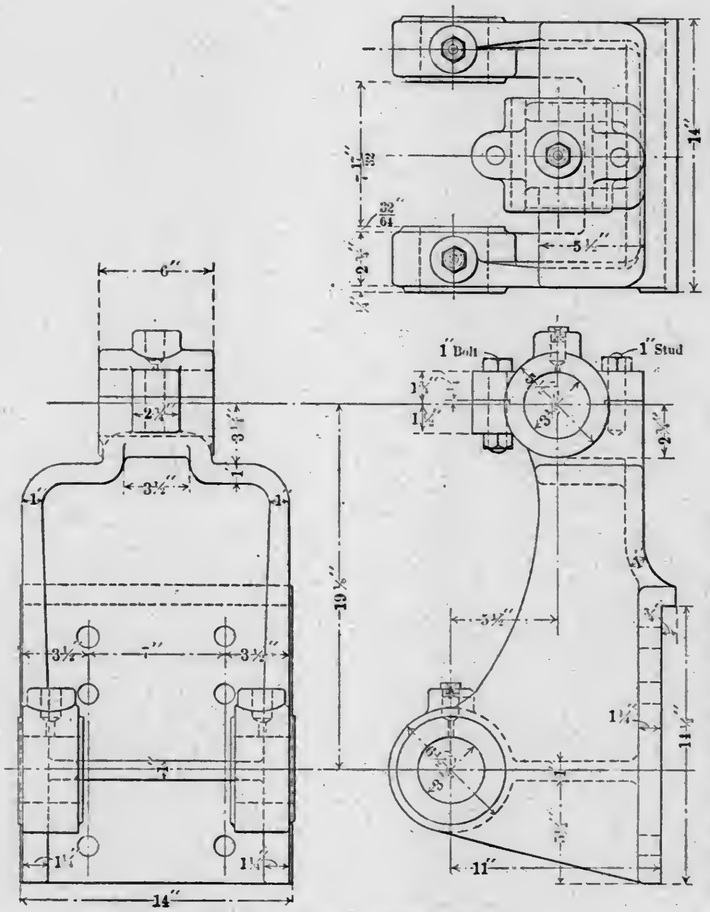
Driving, diameter over tires	69 in.
Driving, thickness of tires	3½ in.
Driving journals, main, diameter and length	10 x 12 in.
Driving journals, others, diameter and length	9 x 12 in.
Engine truck wheels, diameter	33 in.
Engine truck journals	6½ x 10 in.

BOILER.

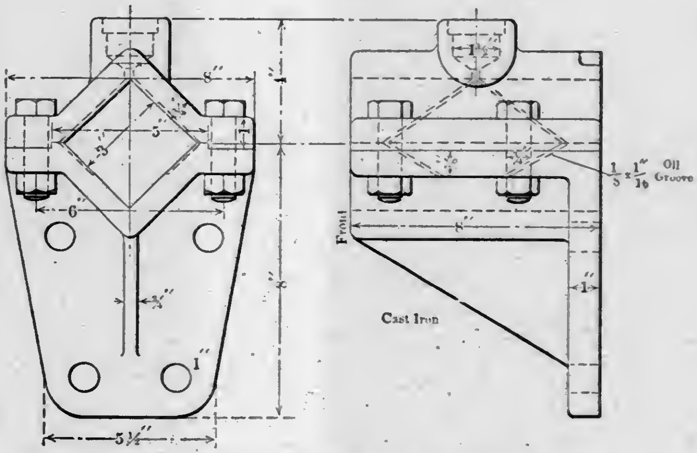
Style	E. W. T.
Working pressure	200 lbs.
Outside diameter of first ring	68 in.
Firebox, length and width	101¾ x 67¼ in.
Firebox plates, thickness	3/8 & 1/2 in.
Firebox, water space	F-4, S. & B-3½ in.



FRAME CROSS TIE SUPPORTING LINK AND REVERSE SHAFT BEARINGS.



LINK AND REVERSE SHAFT BEARINGS.



VALVE STEM BEARING ON GUIDE YOKE.

Tubes, number and outside diameter	364—2 in.
Tubes, length	15 ft. 1½ in.
Heating surface, tubes	2,867 sq. ft.
Heating surface, firebox	172 sq. ft.
Heating surface, total	3,039 sq. ft.
Grate area	47.7 sq. ft.
Smokestack, height above rail	15 ft. 8½ in.
Center of boiler above rail	9 ft. 8 in.

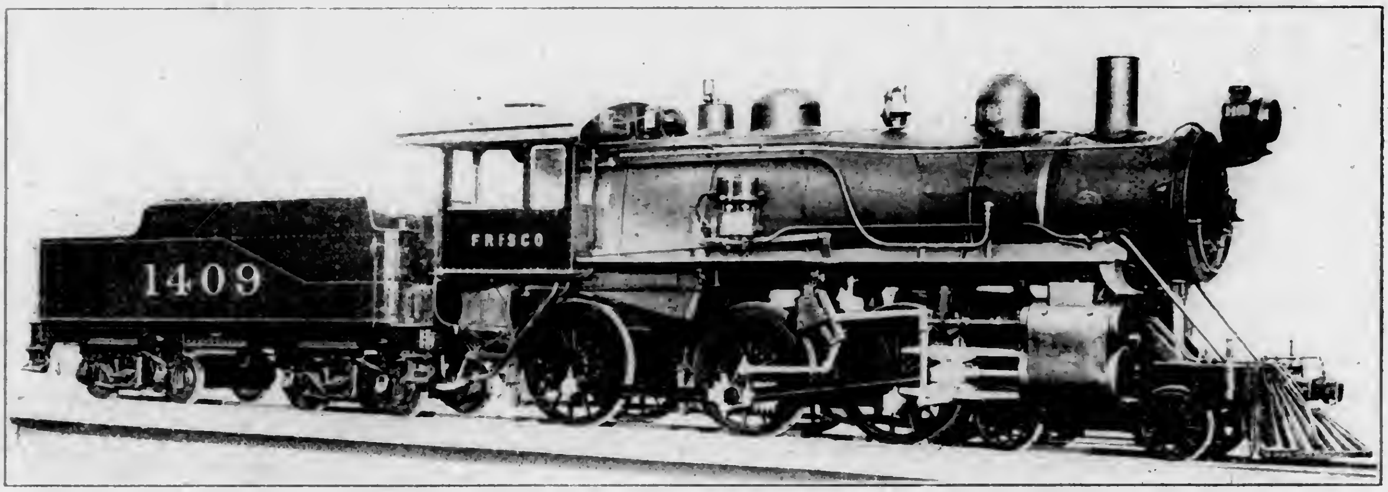
TENDER.

Tank	Water Bottom
Frame	Steel
Wheels, diameter	33 in.
Journals, diameter and length	5½ x 10 in.
Water capacity	6,000 gals.
Coal capacity	12 tons.

PRODUCER GAS ENGINE PLANT FOR RAILWAY REPAIR SHOP.—Among the first railway repair shops in which the suction producer and gas engine have been introduced is the main car repair shop of the Minneapolis & St. Louis Railroad at Minneapolis. This shop being in the vicinity of a fashionable residence district, it was desirable to suppress the smoke nuisance, and in making the necessary improvements in the power plant it was decided to use gas engines. The elimination of smoke has been effected and it is reported that in operation the plant shows a low cost for fuel. The coal used is anthracite pea and the consumption, when the engines are carrying 75 to 80 per cent. of normal rate, is only one pound per brake horsepower, and the total cost of fuel, attendance and operation is given as $1.24 per horsepower per month. There is one engine of 140 horsepower for the mill and two engines of 80 horsepower for driving electric generators. The first cost of large gas engine plants is virtually on a par with first-class reciprocating engine plants, about $100 per horsepower, while the costs for fuel, for labor, handling of coal and ashes, and for maintenance, are each reported to be about one-half as much per unit as the corresponding items for a plant using steam engines and boilers.—*Railway Age.*

COST OF WATCHING THE RAILROADS.—A communication from the Interstate Commerce Commission transmitted to the house of representatives states that it will cost the United States government $750,000 a year for the supervision of railroad accounts under the present Interstate Commerce act. The document contains a letter from Commissioner Harlan, in which he says that it will require a board of examiners, composed of 285 men, especially trained in the methods of railway accounting, to supervise the accounts and practices of the steam railroads. This estimate does not cover such examiners as may be required later to supervise the accounting methods of express companies, water lines and pipe lines.—*Railway and Engineering Review.*

On Wednesday, March 18, the last open space in the Blackwell's Island Bridge, in New York City, was connected and the headings of the last of the four Pennsylvania Railroad tunnels under the East River were joined.



TEN-WHEEL PASSENGER LOCOMOTIVE—ST. LOUIS & SAN FRANCISCO RAILROAD.

TEN WHEEL PASSENGER LOCOMOTIVE.

St. Louis & San Francisco Railroad.

The Baldwin Locomotive Works has recently delivered to the St. Louis & San Francisco Railroad ten passenger locomotives of the ten-wheel type, which are among the heaviest engines of this class ever built by that company.

About a year ago there appeared in these columns (Page 104, 1907), a description of some locomotives of the same type for passenger service, built for this railroad by the American Locomotive Company, which weighed 183,000 lbs. total and had 21 x 26 in. cylinders. They were equipped with Walschaert valve gear and an extended wagon top type of boiler, having a total heating surface of 2,054 sq. ft. The locomotives in this later order are considerably larger and more powerful and exceed the earlier ones in every dimension except grate area. The boiler is 68 in. diameter at the front ring as compared with 66⅛ in.; there are 304 2 in. tubes in place of 318, the cylinders are 23 x 26 in., the weight has been increased to 194,450 lbs., of which 111,050 is on drivers, and the tractive effort delivered with the same steam pressure is 33,900 instead of 28,300. A comparison of the ratios between these two designs will show that the increased power is based on the increased amount of heating surface backed up with probably a somewhat higher rate of combustion on the grates.

The accompanying table will permit an easy comparison of this design with [illegible] engines of this type, and in[illegible]

Road	S. F.	[illegible]	[illegible]	N. Y. C.	C. & N. W.
Total weight	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Weight on drivers	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Tractive effort	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cylinders	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diam. drivers	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Steam pressure	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total heating surface	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
B. D. ratio	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Reference in Amer. Eng.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

dicates that this power, while primarily designed for passenger service, will also be found to be very satisfactory for fast freight service.

The most interesting feature of this design is found in the arrangement of the Walschaert valve gear, which, as do all the later designs, shows some improvement over the earlier arrangements. The most striking feature is the placing of the combination lever behind the guide yoke with the union link extending back from the cross head, and the employment of a very long valve stem, having a guide and bearing bolted to the guide yoke. This shortens up the radius bar considerably and permits the locating of the link somewhat further back than has been the previous practice in ten-wheel engines. This location in turn reduces the size and weight of the link support, which is fastened to the frame cross tie. It also compels the use of a short eccentric rod, the errors of angularity being largely overcome in this case by a long extension on the link. The reverse shaft bearing and link bearing are both incorporated in one casting bolted to the frame cross tie, the simplicity and lightness of which are shown in the detail illustration. This arrangement of the gear permits the use of the simpler design of guide yoke and allows it to be located much nearer the back ends of the guides.

The relief valve, noticed on top of the valve chest, consists simply of a plate resting on top of a horizontal seat and normally covering openings leading to the live steam ports. When the throttle is opened this plate is held down by boiler pressure acting on its upper surface. Excessive pressure within the cylinders, which acts upon a smaller area than the boiler pressure above, lifts this plate from its seat and opens communication between the two live steam ports.

The general dimensions, weights and ratios of these locomotives are as follows:

GENERAL DATA.

Gauge	4 ft. 8½ in.
Service	Passenger
Fuel	Bit. Coal
Tractive effort	33,900 lbs.
Weight in working order	194,450 lbs.
Weight on drivers	111,050 lbs.
Weight on leading truck	53,400 lbs.
Weight of engine and tender in working order	315,000 lbs.
Wheel base, driving	15 ft. 10 in.
Wheel base, total	26 ft. 10 in.
Wheel base, engine and tender	57 ft. 10 in.

RATIOS.

Weight on drivers ÷ tractive effort	4.16
Total weight ÷ tractive effort	5.72
Tractive effort x diam. drivers ÷ heating surface	770.00
Total heating surface ÷ grate area	61.00
Firebox heating surface ÷ total heating surface, per cent	5.65
Weight on drivers ÷ total heating surface	46.50
Total weight ÷ total heating surface	63.50
Volume both cylinders, cu. ft.	12.50
Total heating surface ÷ vol. cylinders	243.00
Grate area ÷ vol. cylinders	3.79

CYLINDERS.

Kind	Simple
Diameter and stroke	23 x 26 in.

VALVES.

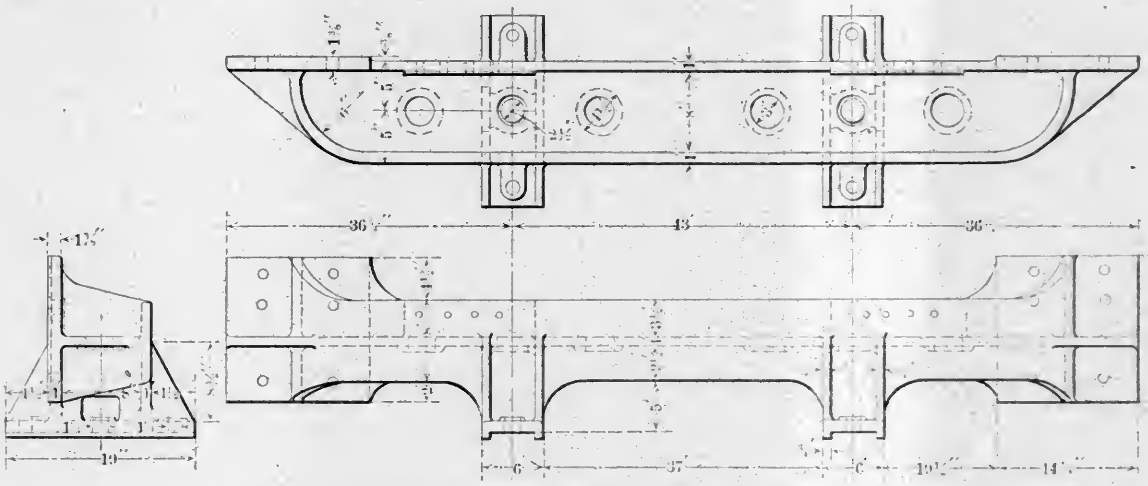
Kind	Piston
Diameter	13 in.
Greatest travel	6 in.
Outside lap	1 in.
Inside clearance	⅛ in.
Lead, constant	¼ in.

WHEELS.

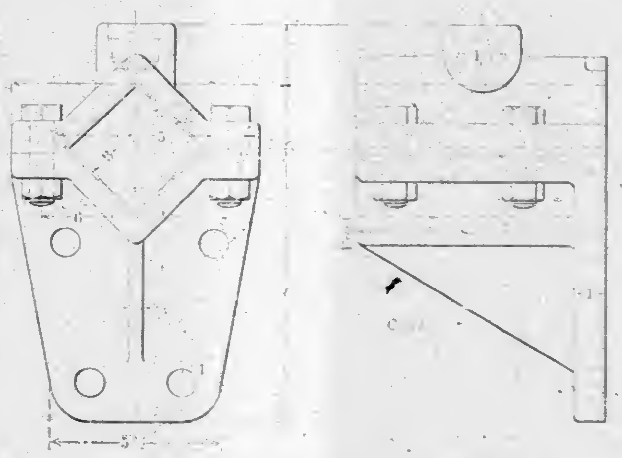
Driving, diameter over tires	69 in.
Driving, thickness of tires	3½ in.
Driving journals, main, diameter and length	10 x 12 in.
Driving journals, others, diameter and length	9 x 12 in.
Engine truck wheels, diameter	33 in.
Engine truck journals	6½ x 10 in.

BOILER.

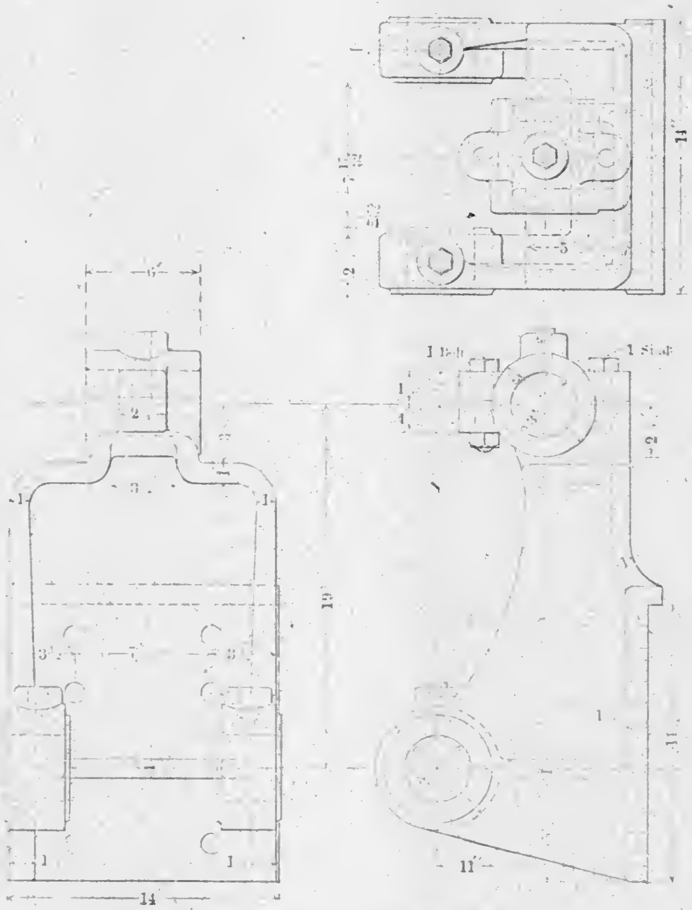
Style	E. W. T.
Working pressure	200 lbs.
Outside diameter of first ring	68 in.
Firebox, length and width	101[illegible] x 67[illegible] in.
Firebox plates, thickness	[illegible] & ½ in.
Firebox, water space	[illegible] S. & B. [illegible] in.



FRAME CROSS TIE SUPPORTING LINK AND REVERSE SHAFT BEARINGS.



VALVE STEM BEARING ON GUIDE YOKE.



LINK AND REVERSE SHAFT BEARINGS.

Tubes, number and outside diameter	364—2 in.
Tubes, length	15 ft. 1¼ in.
Heating surface, tubes	2,867 sq. ft.
Heating surface, firebox	172 sq. ft.
Heating surface, total	3,039 sq. ft.
Grate area	47.[illegible] sq. ft.
Smokestack, height above rail	15 ft. 8½ in.
Center of boiler above rail	9 ft. 8 in.

TENDER.

Tank	Water Bottom
Frame	Steel
Wheels, diameter	33 in.
Journals, diameter and length	5½ x 10 in.
Water capacity	[illegible] gals.
Coal capacity	12 tons.

PRODUCER GAS ENGINE PLANT FOR RAILWAY REPAIR SHOP.—Among the first railway repair shops in which the suction producer and gas engine have been introduced is the main car repair shop of the Minneapolis & St. Louis Railroad at Minneapolis. This shop being in the vicinity of a fashionable residence district, it was desirable to suppress the smoke nuisance, and in making the necessary improvements in the power plant it was decided to use gas engines. The elimination of smoke has been effected and it is reported that in operation the plant shows a low cost for fuel. The coal used is anthracite pea and the consumption, when the engines are carrying 75 to 80 per cent. of normal rate, is only one pound per brake horsepower, and the total cost of fuel, attendance and operation is given as $1.24 per horsepower per month. There is one engine of 150 horsepower for the mill and two engines of 80 horsepower for driving electric generators. The first cost of large gas engine plants is virtually on a par with first-class reciprocating engine plants, about $100 per horsepower, while the costs for fuel, for labor, handling of coal and ashes, and for maintenance are each reported to be about one-half as much per unit as the corresponding items for a plant using steam engines and boilers.—*Railway Age.*

COST OF WATCHING THE RAILROADS.—A communication from the Interstate Commerce Commission transmitted to the House of representatives states that it will cost the United States government $750,000 a year for the supervision of railroad accounts under the present Interstate Commerce act. The document contains a letter from Commissioner Harlan, in which he says that it will require a board of examiners, composed of 288 men, especially trained in the methods of railway accounting, to supervise the accounts and practices of the steam railroads. This estimate does not cover such examiners as may be required later to supervise the accounting methods of express companies, water lines and pipe lines.—*Railway and Engineering Review.*

On Wednesday, March 18, the last open space in the Blackwell's Island Bridge, in New York City, was connected and the headings of the last of the four Pennsylvania Railroad tunnels under the East River were joined.

(Established 1832).

AMERICAN ENGINEER AND RAILROAD JOURNAL.

PUBLISHED MONTHLY

BY

R. M. VAN ARSDALE

J. S. BONSALL,
Business Manager.

140 NASSAU STREET, NEW YORK

R. V. WRIGHT,
E. A. AVERILL, } Editors.

MAY, 1908

Subscriptions.—*$2.00 a year for the United States and Canada; $2.50 a year to Foreign Countries embraced in the Universal Postal Union. Remit by Express Money Order, Draft or Post Office Order. Subscription for this paper will be received and copies kept for sale by the Post Office News Co., 217 Dearborn St., Chicago, Ill. Damrell & Upham, 283 Washington St., Boston, Mass. Philip Roeder, 307 North Fourth St., St. Louis, Mo. R. S. Davis & Co., 346 Fifth Ave., Pittsburg, Pa. Century News Co., 6 Third St., S. Minneapolis, Minn. W. Dawson & Sons, Ltd., Cannon St., Bream's Buildings, London, E. C., England.*

Advertisements.—*Nothing will be inserted in this journal for pay,* EXCEPT IN THE ADVERTISING PAGES. *The reading pages will contain only such matter as we consider of interest to our readers.*

Contributions.—*Articles relating to Motive Power Department problems, including the design, construction, maintenance and operation of rolling stock, also of shops and roundhouses and their equipment are desired. Also early notices of official changes, and additions of new equipment for the road or the shop, by purchase or construction.*

To Subscribers.—*The* AMERICAN ENGINEER AND RAILROAD JOURNAL *is mailed regularly to every subscriber each month. Any subscriber who fails to receive his paper ought at once to notify the postmaster at the office of delivery, and in case the paper is not then obtained this office should be notified, so that the missing paper may be supplied.*

When a Subscriber changes his address *he should notify this office at once, so that the paper may be sent to the proper destination.*

CONTENTS

TENDER TRUCK SPRINGS

On page 394 of the September, 1906, issue of this journal a tender truck was described which, by changing the springs, was interchangeable for both freight and passenger locomotives. The passenger tender truck was equipped with elliptical springs and the freight truck with helical springs. After they had been in service for a short time it was found that the tenders with the helical springs were not at all satisfactory because of the jerky up and down movement which they gave to the tender, shaking down the coal and otherwise interfering with the comfort and convenience of the firemen. The helical springs on the front trucks have been replaced with elliptical springs and very good results are now being obtained.

STANDARD SIZE CATALOGS

Since the adoption by the M. C. B. Association of standard sizes for catalogs and other technical literature of a like nature the supply companies have quite generally seen the features of advantage of this plan and are holding to standard sizes. A recent re-indexing of the catalog files in this office showed that about 75 per cent. of the companies are issuing catalogs in standard sizes. Of the other 25 per cent. there were found practically all conceivable shapes and sizes, one, for instances, measuring 5⅜ by 6⅞ in., with absolutely no reason for departure from the standard so far as illustrations were concerned. It was also found in a number of cases that, although the body of the catalog was of standard size, the heavy paper cover was extended about one-quarter of an inch on all sides, making it most inconvenient for filing and of very untidy appearance. Of the 25 per cent. mentioned, in the re-indexing it took an exceedingly valuable catalog to be saved from the waste basket. It will well pay all supply companies in issuing literature to remember the standard sizes of 3½ by 6 in.; 6 by 9; and 9 by 12 in.

RELIABILITY OF THE INDIVIDUAL MOTOR DRIVE FOR MACHINE TOOLS.

Probably a greater proportion of the machine tools in the McKees Rocks shops of the Pittsburgh & Lake Erie Railroad are equipped with individual motor drives than in any other railroad shop in this country. During the year 1907 the average delay to tools, due to motor troubles, was about seventeen minutes. There are 84 motors in use for driving machine tools and during the year there were only 93 delays, or an average of 1.1 per motor per year. The longest delay was 1¼ hours. The total time of all delays during working time was 26½ hours. Assuming an average rate of 27½c. per hour for the machinist's wages and a surcharge on each machine of 50c. per hour, would bring the total loss due to delays to only about $20.00 for the year. These delays include all time lost due to the failure of electrical apparatus at the machine. As a matter of fact the greater part of the time lost was due to trouble with the controllers and not with the motor itself. When it is considered that these motors operate on the multiple voltage system, the controllers furnishing 21 speed steps over a range of about 3 to 1, it is remarkable that so little trouble occurred, especially as these controllers were among the first of this type that were placed in operation.

A comparatively large amount of silent chain is also used in this shop, especially in connection with the application of individual motor drives to the older machine tools, which were transferred from the old shops. This chain has been in operation for about five years with splendid results, except that on a wheel press and a punch and shear, where the work is intermittent, the chains had evidently not been properly selected. The one on the wheel press was removed and replaced by a pinion and gear, while the chain on the punch and shear was doubled in width. On some of the smaller drill presses the chains wore quite rapidly due to their not being of sufficient capacity. Except for these cases, which were due to an error in selecting the proper size chain, it has given very good results and is regarded as more satisfactory than the direct gear and pinion drive.

The application of individual motors to the older tools was described in connection with a series of articles which were published in this journal during the years 1903 and 1904. A description of the locomotive repair shops at McKees Rocks was also published during these years.

BOILER EFFICIENCY

In his paper on the heat balances in locomotives, presented before the Institution of Mechanical Engineers of Great Britain, parts of which are given in this issue, Mr. Lawford H. Fry states that some recent tests on the Pennsylvania Railroad locomotive testing plant at Altoona show that the boiler efficiency is independent of the grate area and that it makes no difference whether the same total amount of coal per hour is burned on 55.5 sq. ft. of grate area, at 72 lbs. per sq. ft. per hour, or on 29.76 sq. ft. at 134 lbs. per sq. ft. per hour. These experiments were all made on the same locomotive and it is explained that the reason lies in the fact that the firebox volume, which was constant, is the controlling factor.

From this it would appear that in the case of a locomotive with large grate area, which did not properly cut its fire, the bushing of the nozzle might be avoided by simply bricking over a section of the grate, thus giving more draft through the fire without decreasing the efficiency of the boiler or the locomotive.

Mr. Fry also arrives at some other interesting conclusions from his study of the St. Louis and Altoona tests, one of which is that the efficiency of the absorption of the heat by a boiler is practically independent of the rates of combustion and evaporation and that under all conditions of working the heating surface will absorb about 80 per cent. of the heat produced by the combustion. This figure seems to be more or less independent of the design of the boiler and of the ratio of the heating surface to grate area. From this it will be seen that the efficiency of the boiler as a whole is mainly determined by the efficiency of the combustion, which in the same firebox falls rapidly as the total amount of coal burned per hour is increased.

BURNING LIGNITE COAL IN LOCOMOTIVES.

There are large deposits of lignite in the northeastern part of Wyoming; the southeastern part of Montana; the western portion of North Dakota, and the northwestern part of South Dakota. As may be seen from the analysis on the first page of this issue, this coal is very low in ash, although the amount of moisture is higher than that in the ordinary bituminous coal. It is free from slate and rock and burns easily, with no clinkering. It can be mined cheaply, but disintegrates quickly when exposed to the air, so that it must be used as soon as possible after being removed from the mine. The railroads in this northwestern district have made several attempts to burn this coal, because of the great expense of hauling bituminous coal from Iowa, Illinois, Missouri and the coal producing states in that district. If the lignite can be burned successfully it will not only greatly reduce the cost of locomotive fuel in this district, but will tend to develop the coal mining industry along the lines which pass through this territory.

While the lignite is used more or less for industrial purposes the fact that it disintegrates so quickly interferes with the mines operating and storing up coal during the time of year when the industrial requirements are low; if the railroads could use the coal it would keep the mines operating efficiently the year round. While all of the roads passing through the district have studied the matter of its use closely and have experimented with it more or less, only one road is using it extensively at the present time. The objection to its use in locomotives is in the fact that it is very light and the sparks which are carried out through the stack set fire to the surrounding country. The small particles of burning lignite which pass out hold the fire for a long time until they are entirely consumed. The climate in this district is particularly dry, so much so that it has been said that the trainmen must be very careful as to the language they use while passing through it in the dry season in order not to set it on fire. The Burlington Railroad has been experimenting with this fuel for a number of years and has finally perfected the grate and front end arrangements of its lignite burning engines, so that when the engines are evenly and properly fired, practically no sparks escape. However, under the average condition of firing, even with the best arrangements which have been worked out, some few sparks do escape. It would appear that this difficulty can be entirely relieved by the introduction of a successful spark arrester.

A number of the roads in the middle west are making a careful study of this question at present and it is quite probable that its final and complete solution is near at hand. The progress which has been made on the Burlington, which at present is burning about 3,000 tons of this fuel per day, is carefully traced in an article, by Mr. O. N. Terry, on "Lignite Burning in Locomotives" on page 161 of this issue.

NEW YORK SUBWAY CARS.

At the present time the New York subway car equipment consists of 500 composite cars, in which some wood is used, 300 all metal, strictly fireproof cars and 50 all metal cars, which have been recently delivered. The first 800 cars are practically the same size, with the same seat and door arrangement. The last 50 have wider doors and have only one bank of cross seats in the center of the car. There are 10 longitudinal seats on each side, instead of nine, making the seating capacity of the last 50 cars 48 instead of 52, as on the first cars.

The operation of these cars in subway service has disclosed certain fundamental defects in design which should be remedied before the subway can furnish the speed, comfort and capacity which the passenger has a right to expect. Mr. Bion J. Arnold recently submitted an extensive and very complete report upon the subway car to the Public Service Commission for the First District of the State of New York. His conclusions are that the present car when provided with an additional side door, located near each end, thus making four doors in each side of the car, will best meet the conditions of the present subway and that when these cars are properly operated through the stations as rapidly as the signal system, when modified as recommended in a previous report, will permit, a marked increase in the capacity and comfort of the subway will be realized. The following is a brief abstract of Mr. Arnold's report:

At each express station the passenger has the privilege of transferring from the local trains to the express trains, and vice versa, and to facilitate this transferring the five express stations are arranged with island platforms between the tracks, so that the passengers can leave the trains of one service, cross the platform, and directly enter the cars of the other service. This privilege is much used, and even abused to a great extent; owing to the excessive use of this transfer privilege many passengers, in traveling from their starting points to their destinations, are loaded and unloaded twice, and a large number of them three times, so that many of the passengers use the car doors four times, and some six times. On account of the excessive use of the doors the present type of car, which ordinarily gives satisfactory service, has proved to be entirely inadequate for the subway.

At the present time it is possible, except on very busy days, to get 30 trains an hour through the limiting stations on both the local and the express tracks. During rush hours the cars often carry twice as many passengers as there are seats and during the height of the rush periods there are times when three times as many passengers are carried on some express cars as there are seats, although the latter condition exists for only short periods of time on very busy days. Since the extension of the subway to Brooklyn the time table has called for 40 express trains per hour between 96th street and Brooklyn Bridge during the rush periods. The delays of the trains at the station platforms, however, have seriously interfered with the carrying out of this schedule, and although there are parts of the system where 40 trains per hour are supplied during certain periods of the day, this rate is not maintained at the critical part of the

rush hour period, the time when it is most needed. In other words, as soon as the demand for seats increases beyond a certain limit the supply of seats begins to decrease.

Analysis of Delays at Station Platforms.

The present arrangement of loading and unloading passengers, through the same end doors of the cars, is the chief cause for the inefficient operation during the rush hour period. An analysis of the average time required by express trains at a station platform during the height of the rush hours shows the following figures:

		Average, Seconds.
1.	To open doors of cars after train has stopped	2
2.	To unload an average of 163 passengers through 14 doors (15 to 50 seconds)	20
3.	To load an average of 206 passengers through 14 doors (15 to 30 seconds)	20
4.	To close the car doors and give the signal by means of bell rope to motorman	13
5.	Total average time of express trains at station platforms between stopping and starting during the height of the rush hours	55

Defects in Present Arrangement.

Apparently the only permanent way to improve these conditions is either to reduce or abandon the transfer privilege, or to change the car. While it may be contended that such convenient means of transferring at so many points should not have been provided, it is Mr. Arnold's opinion that this privilege, having been established, cannot now be withdrawn, and that the only remedy, therefore, is to change the cars.

The present car works very well during periods of light and fairly heavy travel, but as soon as it is called upon to carry upwards of 100 passengers the single end doors become a decided disadvantage and their inefficiency in handling large crowds seriously interferes with the prompt movement of trains. As the limit of capacity, under present circumstances, would be the maximum carrying capacity of the car, it is essential that a type of car be used in which this limit can be easily and quickly reached. To state the case briefly, the principle defect in the present car is due to the fact that a definite and ready circulation of traffic is not provided for and that owing to the lack of sufficient side doors, properly located, the maximum carrying capacity of the car cannot be easily and quickly reached.

In a study of the signal system it was found that trains could be run between stations on a headway of 90 seconds, or at the rate of 40 trains per hour. Because of delays at the station platforms and also on account of the arrangement of signals on the tracks approaching the stations it is just possible, under present conditions, to pass 30 trains an hour through the busiest stations during rush hours. If the present arrangement of signals is retained the only possible way to secure an increase in the capacity of the subway from 30 trains per hour to 40 trains per hour is to scrap, or use elsewhere, the entire subway car body equipment and build new cars at an expense of at least $5,000,000, and re-arrange the present platforms, which is practically prohibitive.

The most economical and efficient way, as well as the quickest, to secure a capacity of 40 trains per hour is to improve the signal system, as recommended in a previous report, and at the same time alter the present cars sufficiently to limit the platform waits to a maximum of 35 seconds. It should be understood that 35 seconds is the limit which if exceeded would at once affect the headway and that the average platform wait should, therefore, be less than this in order to provide for operating exigencies.

To secure this result it is evident that the loading and unloading must be carried on at the same time. Some improvements should also be expected from the use of the pneumatic door handling equipment and the electric door signal. These changes should bring the actual wait at the station platform down to the following figures:

		Seconds.
1.	To open doors after train stopped	2
2.	To unload 163 passengers through 14 doors, and to load 206 passengers through separate doors, both processes being carried on at the same time	20
3.	To close doors and give signal to motorman	8
4.	Total *average* time of trains at express stations during rush hours should not exceed	30

It is plain that in order to run 40 trains per hour through the subway it is essential that more door openings be provided than are found in the present cars.

Requirements of a Successful Subway Car.

A successful car for the present subway should possess as many as possible of the following requirements:

1. Separate entrances and exits.
2. A space which can be cleared so as to be ready to quickly receive the passengers boarding a car.
3. Convenient means of circulation inside the car.
4. Standing-room space contiguous to the exits.
5. As many cross-seats as practicable.
6. Exit and entrance doors sufficiently removed from each other to allow for the car stopping convenient to guiding rails on the platforms.
7. Doors located so as to minimize the danger from open spaces at curve platforms.

The various cars may be classified in accordance with the number of doors in the sides of the cars as follows:

Cars with central side door and end doors.
Cars with two quarter side doors.
Cars with three doors near center.
Cars with multi side doors.
Cars with double doors near ends.

Each one of these types may have seats of either the longitudinal, the cross "back-to-back," or of the "walk-over" style, or a combination of two or more styles.

The advantages and disadvantages of each of the above type of cars are considered in Mr. Arnold's report and several seating arrangements are presented for each type.

Cars With Central Side Doors and End Doors.

After a thorough discussion of this type of car, Mr. Arnold comes to this conclusion: "The successful use of the central side door in terminal work does not furnish a precedent which demonstrates that this type of car would be satisfactory under subway conditions, whereas the failure of the center door on the Boston subway, to reduce the length of stop to much less than the time required in the New York subway, even with the present end doors, does not furnish any encouragement toward rebuilding the present subway cars so as to provide them with center doors." Although signs were posted in the Boston cars and the guards and station attendants were instructed to have the passengers enter the cars at the end doors and leave by the center doors, it was found that the passengers could not be controlled sufficiently to maintain this much desired circulation. This type of car is being used in the Hudson tunnels successfully, but the conditions are very different from those in the subway.

Following this is an extensive discussion of the various seating arrangements of this type of car. This is followed by a discussion of cars with multi side doors, such as used on the Illinois Central Railroad.

Multi Side Door Car.

To use the multi side door car would necessitate the scrapping of the car bodies of the present equipment and of changing the station platforms. To use these cars exclusively it is also necessary that the multi side doors be promptly closed by the guards. In Chicago there is apparently no difficulty in doing this, but the traffic in the subway during rush hours is fully ten times as much as that on the Illinois Central during the corresponding period. As experience in the subway has demonstrated that in order to close the car doors during the rush hour period a corps of uniformed, trained, platform guards, in addition to the train guard, is absolutely necessary, it is difficult to see how the car doors could be closed promptly, thus limiting the platform delays, unless the stream of passengers was stopped before it reached the loading platform. This would necessitate a radical re-arrangement of the present platforms.

If the multi side door car is to be considered for future subways, the station platforms should be arranged so that the un-

loading can be done upon one station platform and the loading can be accomplished from another and separate platform.

A number of different seating arrangements are discussed for multi side door cars for both the present and future subways.

The type of car recommended by Mr. Arnold for the present subway is then considered.

Cars With Double Doors Near Ends.

Without weakening the present car, or adding materially to its weight, it is possible to introduce additional side doors, one near each end of each side of the car and as near as practicable to the present end doors, the distance between the doors being at least sufficient to furnish a pocket for the sliding doors.

These additional doors can be added without disturbing the present seating arrangement of the car to any great extent. It is true that the introduction of these doors will make it necessary to remove 8 seats from each car, but the operation of the cars in actual service will make it possible to pass so many more cars through the subway that the loss of 8 seats in each car will be more than offset by the additional seats in the added cars, and the extra standing room, so convenient to the separate exit, is a feature which will decrease the station waits, and thereby increase the schedule speed.

This proposed change in the present car has many advantages which even a casual study will reveal. The new doors can be used for exits, and the present end doors for entrances, thus providing at once the means of carrying on the process of unloading and loading simultaneously and without the present conflict which during rush hours has become so objectionable.

This car provides a separate space for leaving passengers to collect around the exit doors without blocking the space which should be provided for the passengers entering the car. The result will be that passengers will move in and out much more quickly than at present, and the movement of passengers into the car will facilitate the movement of passengers out of the car.

With this car it would be possible to keep the platforms clear of standing passengers, particularly at the time of approaching a station where considerable additional load is to be expected. With the present cars it is impossible to keep the platform clear, as the passengers readily make the excuse that they are getting ready to leave the train at the next station. With a clear platform there should be none of the discomfort now experienced in boarding a crowded car; the passengers will pass rapidly into the empty car vestibule, and can move at once into the space which has been vacated by the leaving passengers.

There should be no hesitation on the part of a passenger in the selection of an entrance with this type of car, as is so often the case with the multi side-door car. Under these circumstances there is no reason why a rate of flow of passengers *in* and *out* of the car amounting to at least 5 passengers per car per second should not be expected with this car with double doors near the end, and this rate is fully as good as the experience in Chicago would lead us to expect from the multi side door cars, even with 8 doors distributed the entire length of the car.

While this type of car provides for setting up and maintaining a circulation, this circulation is not obtained at the expense of comfort to the through passengers, as the circulation is confined to the two ends of the car, and it is therefore not necessary for a passenger boarding a train at one station and getting off at another to pass through half the length of the car, with the attendant discomfort to both himself and to all of the other passengers in the car.

Both the exit and the entrance doors are directly under the eye of the guard, who is thus in a position to accentuate the circulation, and, therefore the rapidity of handling the passengers, by opening the exit door slightly in advance of the entrance door, which can easily be done by either mechanical or pneumatic means. This car lends itself readily to the introduction of platform railings at all of the more important station platforms.

The standing room in this car can be increased during rush hours by folding up the two seats between the doors, and, while this practice is not to be commended, there will be times, and particularly on heavy days, such as Mondays, when this feature could be utilized.

The present cars can be changed to conform to this arrangement for an expense of about $2,000 for each steel car, and about $1,500 for each composite car.

For the present subway this car seems to possess more advantages and fewer disadvantages, both from the standpoint of the public and the operating company, than any other type, and its use will increase the capacity of the subway sufficiently to fully justify the expense of altering the present cars into cars of this type.

More Compact Seats for Future Cars in Present Subway.

In the present subway cars the space devoted to the cross seats is used in an uneconomical manner. There are 70 inches between the center of the backs of these seats, which is taken up by two 6-inch back cushions, two 18-inch seats and a clear space between seats of 22 inches. Where space is as much at a premium as it is in the subway cars, the arrangement of these seats should be made more compact, and this can be done without sacrificing the comfort now secured with the more liberal spacing. For double side seats, served from a center aisle, a clear distance of 20 inches between seats is sufficient, and the allowance of 18 inches for each seat, together with its back, has been found satisfactory, thus making a total over-all distance of 56 inches for one bank of seats. The width of 18 inches for each passenger for the cross seats and of 19 inches for the longitudinal seats in the present car is good practice.

With the more economical arrangement of cross seats, more space can be devoted to such seats and at the same time the seating capacity of the car can be increased. This improvement should be kept in mind in ordering future cars for the present subway.

Recommendations.

The recommendations, summarized, are as follows:

First—That every car used in regular passenger service in the present subway be provided with two additional side doors, located near the ends.

This car is recommended for the following reasons:

1. The double-door space at each end of the car will greatly reduce the present station waits.
2. The separate exits and entrances will remove the present uncomfortable conflict at the car doors.
3. The present cars can be altered into this type of car without detracting from their structural strength, or materially altering the present seating arrangement.
4. The result in increased carrying capacity due to the changes will abundantly justify the investment.
5. This is the only type of car with additional doors that will not materially increase the present trouble due to curved platforms.

Second—That all cars be provided with either pneumatic or other means for quickly opening and closing the doors, and with signals which will automatically indicate to the motorman when the last door is closed.

Third—That all new cars be of metal and provided with seats more economically arranged.

Fourth—That when the cars of the double end-door type are put into service a system of platform railings be provided to direct the passengers.

Fifth—That for future subways a wider car should be considered. This car may be a multi side-door car, if separate platforms can be arranged for each class of trains, and if the stations can be designed to control the flow of passengers at the entrance to the platform instead of directly at the car doors. If, however, it is found that it is impracticable to design stations with sufficient room for waiting passengers independent of the station platforms, it will probably be found that the best car for future subways is a wide car of the type with double doors near ends.

Sixth—That if it is found that future subways cannot be built without the occasional use of curved platforms, the cars for these future subways should be designed so as to allow the station platforms to extend under the car in such a way that the necessity for sliding platforms will be obviated.

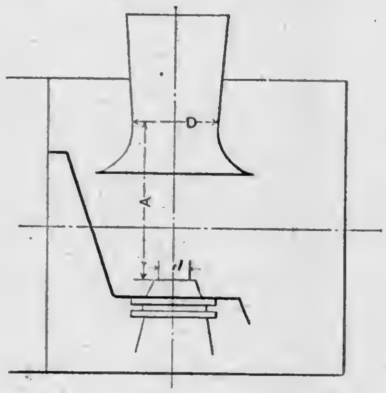
MORE ABOUT SMOKE STACKS.

To the Editor:

In the March number of your Journal, page 85, appeared an article on the subject of smokestacks by Mr. W. E. Johnston, which, while it was evidently the result of much thought, and gave results which would probably be successful in service, could never become popular with builders or users of locomotives to any extent on account of the great variation in stack diameter given for a small variation in the diameter of the exhaust nozzle. Thus for a 4½" nozzle, with a distance from nozzle to choke of 40", Mr. Johnston's diagram would give a stack diameter of 14". Now, suppose we found we could use a 5" nozzle and still have a free steamer, we find we should have equipped the engine with a 15½" stack.

The Master Mechanics' Committee of 1906 ignore the factor of nozzle diameter altogether, making the diameter of stack depend entirely upon the diameter of the smokebox, and the distance from nozzle to choke. While the factor of nozzle diameter undoubtedly should enter into the question, it is only in a slight degree that it affects the stack diameter.

This peculiarity in Mr. Johnston's deductions undoubtedly arose from his attempt to reconcile the recommendations of the three committees of the Master Mechanics' Association, those of 1896, 1903 and 1906, whereas those of 1906 alone are based upon



$$D = \left(d + \frac{A}{6}\right) 1.4. \quad (1)$$

or

$$D = \left(\frac{c}{4} + \frac{A}{6}\right) 1.4. \quad (2)$$

c = Diam. of cylinder.

FIG. 1.

a front end without draft pipes. The committees of 1896 and 1903 made the exhaust jet fill the stack, while the last committee leave a considerable space (shown by the shaded portion of the template, Fig. 2) around the jet for the entrainment of gases. It is for this reason that the stacks of the 1906 committee are larger than those previously used and any attempt to reconcile these results with those previously obtained with the use of draft pipes cannot give a rational progression.

For the purpose of obtaining the correct stack diameter in the drawing room I have found a template of the form shown in Fig. 2 to be very useful. This is made on celluloid or tracing cloth to the scale of the elevation drawing of the locomotive and its form is based solely upon the 1906 tests, except as they are varied slightly by taking the nozzle diameter into consideration. The taper of the exhaust jet (2 in 12) was determined by the 1896 tests, and has since been verified for the type of nozzle commonly used—that with sides tapering to from 1" to 3" of the top.

Mr. A. J. Pitkin, then general manager of the Schenectady Locomotive Works, made tests some years ago by painting the inside of various sizes of stacks and noting where the cinders removed the fresh paint. His results gave an angle of 9°, which is almost identical with a taper of 2" in 12". In fact, this form of the jet for the common type of nozzle has never been called in question. Therefore, we have but to start with the diameter of nozzle, add the height "A" divided by 6, see Fig. 1 (corresponding to a taper of 2 in 12), and multiply by 1.4, a constant giving the proper proportion of space around the jet as determined by the 1906 tests. This gives the first formula.

The second may be used where the size of nozzle is not known, and is based on the rough and ready rule that the nozzle diameter is about ¼ the diameter of the cylinder. This is not accurate enough for exhaust nozzles, but is sufficiently so for smokestacks.

To use the template, place the line giving the proper diameter of exhaust nozzle at the top of the nozzle, and read the diameter of stack from the line nearest the desired location of choke. The taper of stack should correspond with the taper of the jet.

Those who have attempted to use the Master Mechanics' formula for stack diameters, have often been "held up" on the start by the admonition to make "h"—the distance from center line of boiler to top of nozzle—"as great as possible." The question is, how great can it be made? This lower limit is obviously determined by the amount of area desired below the diaphragm

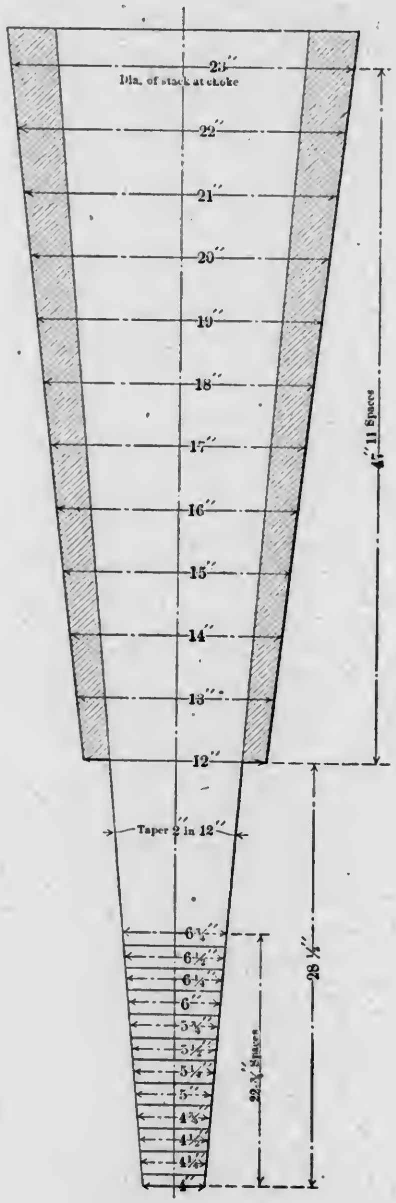


FIG. 2.

plate. For self-cleaning front ends, a damper which may be adjusted to give from ⅝ to ⅞ of the area of the tubes, will be found to give satisfaction. Allow a sufficient space for the working of this damper, and the height of the tip, which should be above the horizontal plate, will give the lowest possible nozzle.

It will be understood from the foregoing, that the rules given apply only to tapered stacks of the form recommended by the 1906 report, without draft pipes, and to the type of nozzle most commonly used. The remarks about dampers apply to "self-cleaning" front ends of the Lake Shore type.

Hal. R. Stafford.

Schenectady, N. Y.

ANNEALING FIREBOX STEEL.

The question as to the advisability of annealing firebox steel is one that does not seem to be generally understood in connection with railroad boiler shop practice. The following notes, for which we are indebted to C. A. Seley, mechanical engineer of the Rock Island Lines, are of interest in this connection.

Authorities are not strong in urging annealing for boiler steel, principally because of the uneven results obtained by reason of crude methods employed, and the fact that exact temperatures that are necessary for results are not obtained. G. G. Mehrtens, Trans. A. S. C. E., 1893, says: "Annealing is of advantage to all steel above 64,000 pounds strength per square inch, but it is questionable whether it is necessary in softer steels. The distortions due to heating cause trouble in subsequent straightening, especially of thin plates." (Kent, page 395.)

Other authorities on boiler work and on metallurgy give the impression that annealing is so little practiced that the majority of boilers are built without it. It is not denied that annealing under proper management may be a benefit, but on account of methods employed, the wisdom of chancing injury is doubted.

Based on these opinions, the necessity for putting side sheets and most crown sheets into an annealing furnace is doubtful. They have not had such an amount of work in most cases as to introduce serious internal strains.

Assuming the necessity for annealing sheets that have been flanged or worked a considerable amount, the authorities have this to say as to proper methods. Kent says (page 395): "The best results from annealing will probably be obtained by introducing the material into a uniformly-heated oven in which the temperature is not so high as to cause a possibility of cracking by sudden and unequal changing of temperature, then gradually raising the temperature of the material until it is uniformly about 1,200 degrees F., then withdrawing the material after the temperature is somewhat reduced, and cooling under shelter of a muffle sufficiently to prevent too free and unequal cooling on the one hand, or excessively slow cooling on the other."

All authorities agree on the following points:

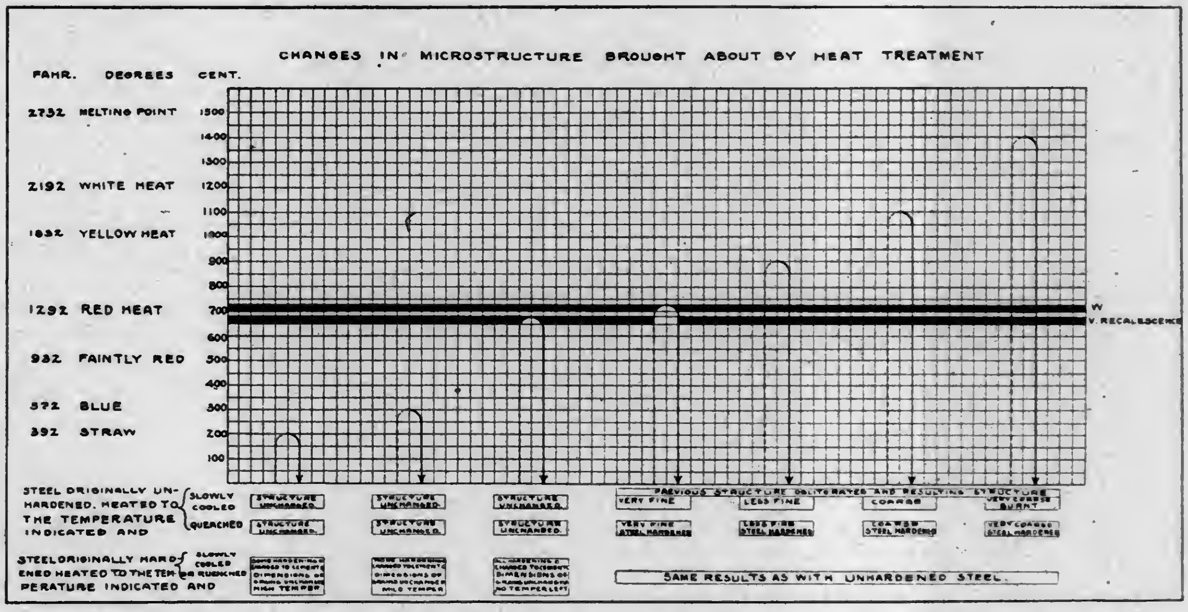
First: The steel should be heated slowly and evenly, the latter point being particularly observed.

Second: The maximum heat should be a bright cherry (Crescent Steel Co.) or medium orange (Wm. Metcalf, in "Manual for Steel Users," page 86). Heat should not go to bright orange or the lemon shades.

Third: As soon as thoroughly heated, as above, it should be removed from the fire, as "every additional moment of heating will only injure the steel ("Manual for Steel Users," page 86). "As soon as it is hot, take it out of the fire, the sooner the better, and cool it as slowly as possible" (Crescent Steel Co.). "Annealing for a short time at moderate temperature does not very largely increase the size of the grain, but prolonged heating at low temperature or comparatively short heating at very high temperatures produces a very coarse grained structure" (Harbord, Metallurgy of Steel, page 686).

Metcalf in "Manual for Steel Users," page 85, explains that steel will assume a structure dependent on temperature, hence the process of annealing is accomplished primarily by the heating to a proper temperature. With steels that harden, the amount of softness retained is a direct function of the length of time of cooling. In non-tempering steel this seems less important, and if reasonably even cooling can be secured, it is believed that nothing is gained by a prolonged period.

The accompanying diagram, illustrating this matter very clearly, is from "Harbord's Metallurgy of Steel." It shows the effect on the grain of the steel by heating up to various temperatures and then cooling down. It shows the height of temperature necessary to produce any change, and the bad effect of too high heat.* It does not show bad effect of long continued low heat.



EFFECT ON THE GRAIN OF STEEL DUE TO HEATING UP TO VARIOUS TEMPERATURES AND THEN COOLING DOWN.
FROM "HARBORD'S METALLURGY OF STEEL."

To make the graphical diagram more valuable, the following table is reproduced from Kent, showing high temperature, judged by color, as follows:

	Deg. C.	Deg. F.
Incipient red heat	525	977
Dull red heat	700	1292
Incipient cherry-red heat	800	1472
Cherry-red heat	900	1652
Clear cherry-red heat	1000	1832
Deep orange heat	1100	2021
Clear orange heat	1200	2192
White heat	1300	2372
Bright white heat	1400	2552
Dazzling white heat	1500 to 1600	2732 to 2912

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION.—The second annual convention of this association will be held at the Hotel Pontchartrain, Detroit, Mich., May 26, 27 and 28, 1908. The subjects, on which there will be committee reports and discussions, include,—the best method of applying and caring for flues; boiler explosions, cause and remedy; applying flexible staybolts; use of oil in locomotive boiler shops and subjects for discussion at the following convention. In addition to these there will be a number of topical discussions and individual papers. The secretary of this association is Harry D. Vought, 62 Liberty street, New York.

WOOD PRESERVATION.—It is estimated that a fence post, which will ordinarily last about two years, will, if given preservative treatment, costing about ten cents, last eighteen years.

COMBUSTION AND HEAT BALANCES IN LOCOMOTIVES.*

By Lawford H. Fry.

The heat losses in a locomotive boiler divide themselves into three main groups:—

1. Loss of heat in the products of combustion.
2. Loss of heat by external radiation.
3. Loss of heat by imperfect combustion.

These three losses with the heat usefully employed in the production of steam must account for all of the heat contained in the coal, and complete the heat balance.

(1) *Loss of Heat in the Products of Combustion.*—The products of combustion consist of certain dry gases, as shown by the analyses of the flue gases, and in addition to these a considerable amount of water-vapor from the water of combustion of the hydrogen in the coal, and from the moisture in the coal and in the air. There is also a trace of sulphuric acid from the combustion of the sulphur. In the St. Louis tests, the water of combustion with the sulphuric acid amounted to 0.40 lb. per pound of coal burned. The moisture in the coal was always in the neighborhood of 1 per cent., and therefore the water-vapor produced, per pound of coal burned, may be taken with sufficient accuracy as 0.41 lb. This comprises the water of combustion and the moisture in the coal as fired. In addition to this vapor, the moisture in the air admitted for combustion must be taken into account. The percentage of moisture in the air can be determined from the wet and dry thermometer readings which were taken.

The mean figures thus obtained are:—

Series 100	1.25	per cent. moisture.
Series 200	1.18	" " "
Series 600	0.62	" " "
Series 800	0.48	" " "

These show that there was a considerable variation in the condition of the various series of tests, but in each series the individual tests do not show a wide variation from the mean.

The weight of the dry gaseous products of combustion per pound of coal burned is 0.54 lb. more than the weight of air supplied per pound of coal.

The amount of heat carried off by the products of combustion depends on the weights of dry gas and water vapor produced per pound of coal burned; on the temperature at which they escape to the smoke-box; and on the specific heat of these substances.

(2) *Loss of Heat by External Radiation.*—This loss was not measured in the St. Louis tests, and, as the loss by unburnt coal was not measured, the radiation loss cannot be determined by difference. It seems, however, permissible to assume that the loss by external radiation is 5 per cent. of the heat utilized by the boiler in evaporation. This cannot introduce any essential error, and it harmonizes with the little that has been published on this subject. Professor Hitchcock shows a loss up to 3.61 per cent., which is 6.3 per cent. of the heat of evaporation. Professor Goss says that experiment has shown that a locomotive running at 28 miles an hour loses by external radiation about 2 per cent. of the power developed.

(3) *Loss by Imperfect Combustion.*—This falls under two heads:—

(i) Loss by production of carbon-monoxide.

(ii) Loss by escape of unburnt coal at chimney and ashpan.

(i) The first-mentioned loss can be calculated from the analysis of the flue gases. The Pennsylvania report shows the percentage of loss in each test by the production of CO. There is a general tendency for the loss by CO to increase as the rate of combustion is increased, but except in Series 100 there is no very serious loss on this score. In Series 100 one individual test shows a loss of 16.33 per cent. by CO. This is due to the rapidity with which the air-supply falls off as the rate of combustion is increased. Evidently the difficulty of getting air to the fire limited the power of this boiler and prevented the rate of combustion being pushed above 90 lbs. of coal per square foot per hour. The relation between the loss of heat by CO and the rate of combustion in this case varies so much that it is difficult to draw a mean curve to express this relation with proper accuracy.

(ii) The loss of heat by the escape of unburnt coal is the most important loss in the heat balance when the boiler is working at full power. The coal escapes unburnt in three ways:—

(*a*) Partially unconsumed as sparks.
(*b*) Partially unconsumed in the ashpan.
(*c*) As unconsumed gas in the products of combustion. This last entails a secondary loss by
(*d*) The sensible heat of the unconsumed gas in the smoke-box.

As the necessary observations were not taken, it is not possible in the present tests to determine the separate value of each of the four items of the loss by unburnt coal, but the total amount of heat lost can be determined by the method which is described below, and which is illustrated by the following example:—

In Test 8,006 there is known	Per cent.
Heat of evaporation	47.20
Heat lost by external radiation	2.36
Heat lost in the production of CO	0.70
	50.26
This leaves as the loss to be divided between the products of combustion and unburnt coal	49.74
	100.00

The heat lost in this test in the products of combustion is 19.30 per cent. of the total heat of the coal *actually burned.* Now, if for example, 25 per cent. of the coal were to escape unburnt, the loss in the products of combustion would apply only on the remaining 75 per cent. actually burned, and would be 0.75×19.3, or 14.5 per cent. of the heat of all the coal fired. Consequently, if P is the percentage of heat lost by coal escaping unburnt, the loss in the products of combustion is $\frac{100 - P}{100}$ 19.3 per cent. of the total coal *fired,* or calling this P_1 we have

$$P_1 = \frac{100 - P}{100}\, 19.3$$

$$\text{and} \quad P_1 + P = 49.74$$

whence, by simple algebra, it is found that P, the loss by unburnt coal, is 37.70 per cent.

The general case is as follows:—

The calculations determine the loss in the products of combustion (including excess air) as a percentage of the total heat of the *coal actually burned.* In the heat balance this loss must be expressed as a percentage of the total heat of *all the coal fired.* If of the coal fired, P per cent. escapes unburnt, the figures must be reduced in the proportion * $\frac{100 - P}{100}$ to show the loss of heat in the products of combustion as a percentage of the heat in the coal fired. Represent this percentage by P_1. Then, if X be the quantity required to complete the heat balance as in the above example,

$$P + P_1 = X.$$

Let P_2 be the percentage of heat lost in the products of combustion per pound of coal burned; then, as explained above,

$$P_1 = \frac{100 - P}{100} P_2 \qquad \text{(4)}$$

$$\text{thence} \quad P + \frac{100 - P}{100} P_2 = X;$$

$$\text{and} \quad P\,(100 - P_2) = 100\,(X - P_2);$$

$$\text{and} \quad P = \frac{100\,(X - P_2)}{100\,(- P_2)} \qquad \text{(5)}$$

and X and P_2 being known, P, the loss by unburnt coal, can be found. Having found P from equation (5), P_1, the loss by the products of combustion per pound of coal fired, is found from

* This is an approximate factor to simplify the calculation. The exact factor would be $\frac{100 - P + d}{100}$, where *d* is the loss by the sensible heat in the unconsumed gas as a percentage of the total heat in the coal fired. The effect of *d* is so small that it is negligible.

* Extracts from a paper presented before the Institution of Mechanical Engineers at the meeting on March 27, 1908.

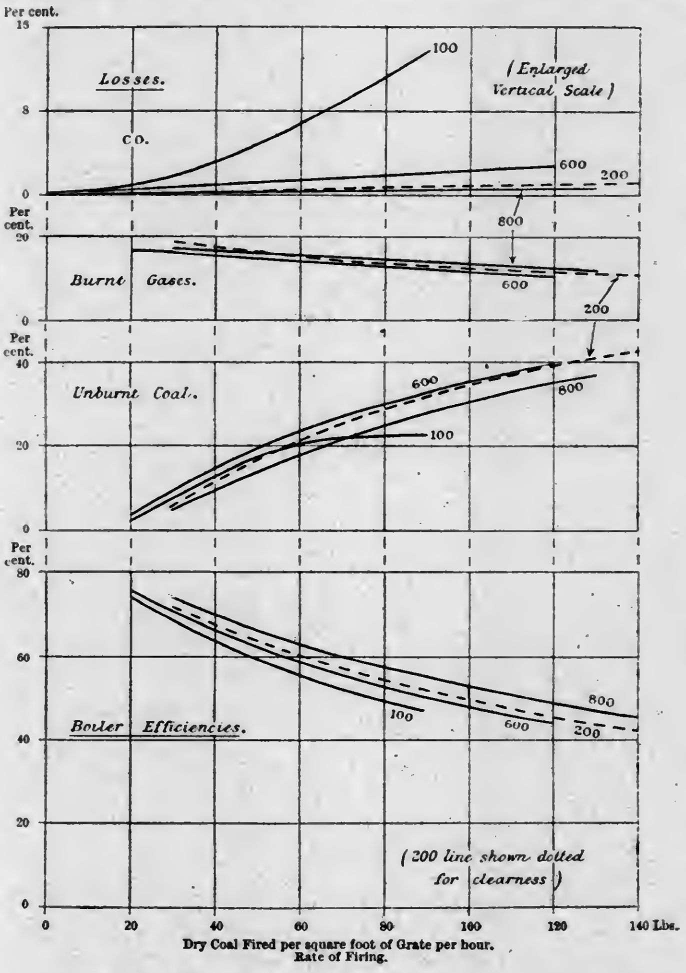
equation (4). The losses thus found complete the heat balance.

TESTS AT ALTOONA WITH BITUMINOUS COAL.

At the close of the St. Louis Exhibition, the Locomotive Testing Plant was transferred to the shops of the Pennsylvania Railroad, where it is now in regular operation. A series of tests were made with one of the standard Pennsylvania Railroad single-expansion Atlantic type locomotives which has cylinders 20½ inches in diameter, with 26 inches stroke, and driving wheels 6 feet 8 inches in diameter.

Three series were run: (a) with the full grate area of 55.5 square feet; (β) with the front of the grate covered with fire-brick so that the effective grate area was reduced to 39.5 square feet, the ratio of grate area to heating surface being 1 to 58.7; (γ) with the effective grate area still further reduced to 29.76 square feet, giving a ratio of grate area to heating surface of 1 to 77.9.

In each of the series four tests were run, one at 80 revolutions per minute with a nominal cut-off at 15 per cent. of the



LOSSES OF HEAT IN LOCOMOTIVE BOILERS—ST. LOUIS TESTS.

stroke, one at 120 revolutions with 20 per cent. cut-off, one at 160 revolutions with 25 per cent. cut-off, and one at 160 revolutions with a cut-off of 32 per cent. This last combination of speed and cut-off taxed the boiler to its maximum capacity.

The coal used contained more volatile matter than that used at St. Louis (35 per cent. instead of 16 per cent.) and was less friable. An ultimate analysis was not made. The proximate analysis of the coal was:—

Fixed carbon	57.2 per cent.
Volatile combustible	35.0 " "
Ash	6.7 " "
Moisture	1.1 " "

[The author here analyzed the processes of combustion in the three series of tests by the same methods used for the St. Louis tests.]

In analyzing this series of tests the rate of combustion has been measured by the total weight of coal fired per hour, and not as for the St. Louis tests by the weight of coal fired per square foot of grate area per hour. This has been done because it was found that if any given quantity of coal, as for instance 4,000 pounds, is fired per hour, the boiler efficiency is independent of the grate area, being practically the same whether the coal is burned on the grate of 55.5 square feet at 72 pounds per square foot, or on the grate of 29.76 square feet at 134 pounds per square foot per hour. The reason, of course, is that in the three series of tests the firebox volume is the controlling factor in the combustion, and is constant; so that a given quantity of coal has in all three tests practically the same opportunity of complete combustion irrespective of the rate at which it is fired per square foot of grate.

SUMMARY OF RESULTS.

St. Louis Tests.—The calculations which have been described have determined for various rates of firing for each locomotive the values of the five items of the heat balance.

(1) Loss by formation of CO.
(2) Loss of heat carried off in the products of combustion.
(3) Loss by coal escaping unburnt.
(4) Loss by external radiation (assumed).
(5) Useful heat of evaporation.

The various values found for these items (with the exception of the radiation) are shown by the accompanying curves. From an examination of these it will be seen that they are calculated for rates of firing of from 20 to 140 lbs. of dry coal per square foot of grate per hour, and that within these limits the four chief items of the heat-balance are affected as follows by an increase in the rate of firing:—

The loss by CO increases from a trace up to about 2 per cent. except in series 100, which is abnormal in this respect, and shows losses up to about 13.8 per cent.

The loss of heat in the gaseous products of combustion decreases from about 18 per cent. to about 11 per cent.

The loss by unburnt coal increases from about 4 per cent. to about 40 per cent.

The boiler efficiency, being affected by the combination of the above changes, decreases from about 74 per cent. to about 43 per cent.

The heat-balances show the result of two separate operations within the boiler, viz., the production of heat by combustion in the fire-box and the absorption of heat by the heating surface. It is interesting to separate the efficiencies of these two operations.

The losses by CO and by unburnt coal are due to incomplete combustion and affect the efficiency of that process only, while the loss of heat in the gaseous products of combustion determines the efficiency of the heat-absorption.

It appears from these figures that the efficiency of the absorption of the heat is practically independent of the rates of combustion and evaporation, so that under all conditions of working the heating-surface absorbs about 81 per cent. of the heat produced by combustion. Approximately, the same figure is obtained for all four boilers, although they vary considerably as regards design and ratio of heating-surface to grate area. The figures show that the efficiency of the boiler, as a whole, is mainly determined by the efficiency of the combustion, which falls rapidly as the rate of combustion is increased.

Although the smoke-box temperature at which the products of combustion escape increases as the rate of combustion increases, the percentage of the total heat carried away by these gases is reduced. This is due to the reduction of the weight of gas produced per pound of coal burned. When the rate of firing is increased from 30 to 130 lbs. per square foot of grate, the weight of the products of combustion is reduced from about 18 lbs. to about 8.5 lbs. per pound of coal fired. For complete combustion about 11 lbs. of air are required, so that when the boiler was forced it was not possible to get enough air through the fire to burn all the coal fired.

The figures obtained show that the locomotive of series 100 is particularly choked for want of air. The author learnt with much interest, after writing the foregoing, that since the tests, the Pennsylvania Railroad has increased the area of the air-inlets in the ashpan of this locomotive, with the result that it steams much more freely and efficiently.

Altoona Tests.—The heat-balances in these tests are calculated for rates of firing ranging from 2,000 to 5,000 pounds of coal per hour. Within these limits, which correspond to the range covered by the tests at St. Louis, the four chief items of the balance are affected as follows by an increase in the rate of firing:—

The loss by CO increases from 0.4 to 2.4 per cent.

The loss of heat in the gaseous products of combustion decreases from about 18 per cent. to about 15 per cent.

The loss by unburnt coal increases from about 10 per cent. to about 28 per cent.

The boiler efficiency decreases from about 68 per cent. to about 52 per cent.

The efficiency of the absorption of the heat actually produced, is, as found in the St. Louis tests, practically independent of the rates of combustion and evaporation, varying only from 78.4 to 79.7 per cent. That is, under all conditions of working, the boiler absorbs about 79 per cent. of the heat produced by combustion, while the boilers at St. Louis showed a constant efficiency of absorption of about 81 per cent.

The Altoona coal, having a higher percentage of volatile matter than that used at St. Louis, did not give quite such a high boiler efficiency at the lightest loads, but it enabled the boiler to be forced to a higher rate of evaporation, and gave a higher efficiency at the maximum boiler power. In the St. Louis tests the highest rate of evaporation obtainable was about 16.3 pounds of water from and at 212° F. per square foot of heating surface per hour, the corresponding boiler efficiency being about 46 per cent. The tests at Altoona show a maximum evaporation of 18.6 pounds of water per square foot of heating surface per hour, with a boiler efficiency of about 51 per cent.

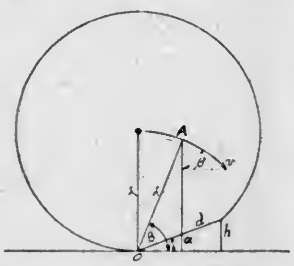
In examining the effect of the variation of grate area in the Altoona tests, it is found that at any given rate of evaporation there is very little difference between the efficiencies of the three series. At the lower rates of evaporation the largest grate gives the lowest efficiency and the smallest grate the highest efficiency; while at the high rates of evaporation the reverse is the case, the largest grate giving the highest efficiency. This is due to the fact that the resistance to the passage of the air through the grate is least with the large grate and greatest with the small grate. At low rates of combustion the most important losses are those due to an excess of air; consequently the large grate has the lowest efficiency. At the high rates of combustion the most important losses are those due to coal escaping unburnt from a lack of sufficient air for proper combustion, and hence the largest grate by admitting the air most freely gives the highest efficiency.

ALLOWABLE LENGTH OF FLAT SPOTS ON CAR AND LOCOMOTIVE WHEELS.*

By E. L. Hancock, Purdue University.

In the absence of experimental data as to the impact to which rails are subjected because of flat spots on car and locomotive wheels, the author has made a theoretical analysis. The development of a formula for the energy with which a flat wheel strikes the rail is as follows:

Let the diagram represent the wheel, of radius, r, having a flat of length, d. Represent the velocity of the train by v. At any instant it may be considered that the kinetic energy of the wheel, with its weight, considered as rotating about the point, O, is the same as if the mass supported by the wheel be regarded as concentrated at its center, that is, its kinetic energy is $\frac{1}{2}Mv^2$, where M is the combined mass of the car and wheel and v is the velocity of train. When the flat spot is in contact with the track the center of the wheel is at the point A, distant below the original position approximately $\frac{1}{4}h$, which is equal to $d^2 \div 4D$, where d is the length of the flat spot and D is the diameter of the wheel. At the point A the mass has a downward velocity equal to $v \cos \beta$.



But $\cos \beta$ equals $d \div D$, so that the kinetic energy with which M strikes the rail is $\frac{1}{2}Mv^2\cos^2\beta = \frac{Mv^2d^2}{2D^2}$, where v is the velocity of train in feet per second, d the length of flat spot in feet and D the diameter of the wheel in feet.

It is assumed that the permissible kinetic energy of the blow caused by the flat spot should not exceed the kinetic energy with which the weight strikes a rail in the prescribed drop test. Hence the energy of the impact as deduced is equated to 380,000 foot-pounds, the energy of a 2,000-pound weight falling through 19 feet.

The weight upon a car wheel being assumed to be 10,000 pounds and the diameter of the wheel 33 inches, the formula becomes

$$d = \frac{29.4}{v} \quad \text{...} \quad (A)$$

While the energy of impact will be slightly increased by reason of the action of gravity increasing the velocity of the mass during the fall through the distance of A below the center, approximately $\frac{h}{4}$, it is found that this is so small as not appreciably to affect the results.

A formula corresponding to (A) for a 72-inch driving wheel, assuming a load of 25,000 pounds on the driver, is:

$$d = \frac{40.6}{v} \quad \text{...} \quad (B)$$

The following table shows the values of d for various speeds:

LENGTH OF FLAT SPOT PERMISSIBLE.

Speed v, in m. p. h.—	33-inch wheel—Formula A. d in ft.	33-inch wheel—Formula A. Factor of safety of 10, d in in.	72-inch wheel—Formula B. d in ft.	72-inch wheel—Formula B. Factor of safety of 10, d in in.
10	2.90	3.48	4.06	4.87
20	1.42	1.68	2.03	2.43
30	0.96	1.15	1.35	1.62
40	0.73	0.87	1.01	1.21
50	0.59	0.70	0.81	0.97
60	0.49	0.58	0.67	0.80
70	0.42	0.50	0.58	0.69
80	0.36	0.43	0.50	0.60
90	0.32	0.38	0.45	0.54
100	0.29	0.34	0.41	0.49

* From a paper presented before the Indiana Engineering Society, January 17, 1908.

Comparison of Alcohol and Gasolene Engines.—A very complete set of tests on the relative value of gasolene and alcohol as producers of power has recently been made by the Technologic Branch of the United States Geological Survey. Over 2,000 tests were made and it is stated that the results show that correspondingly well designed alcohol and gasolene engines, when running under the most advantageous conditions for each, will consume equal volumes of the fuel for which they are designed. The minimum fuel consumption value thus obtained is .8 of a pint per hour per brake h.p. Considering that the heat value of a gallon of denatured alcohol is only about .6 that of a gallon of gasolene, this shows a much better thermodynamic efficiency for the alcohol engine.

Sailors Ride in Railway Gasolene Motor Car.—A feature of the celebration of the arrival of the battleship fleet at San Diego, Cal., was a new gasolene motor car, of the same type as used on the Union Pacific Railway, which the Los Angeles & San Diego Beach Railway has recently installed. The trip of this car to the coast was exceptional for this class of equipment, since it was ordered at such a late date that it was necessary to start it from Omaha without the customary breaking in trials. The car left Omaha on April 9 at 5 A. M. and arrived at Los Angeles at 3 P. M., April 13, having made the entire run without mishap or delay of any kind.

The Speed and Acceleration Problem

By G. E. [illegible]

[illegible] THE CHARACTERISTIC CURVES OF AN EXISTING OR PROPOSED LOCOMOTIVE, A METHOD OF ACCURATELY DETERMINING THE SPEED AND TIME WHICH IT WILL GIVE WITH ANY ASSUMED TRAIN FOR ANY PARTICULAR SECTION OF AN EXISTING OR PROPOSED ROAD IS DEMONSTRATED IN THIS ARTICLE.

The necessity occasionally arises for estimating the time in which a proposed motive power not yet built, or to be altered, can pass over an existing road or a proposed line. This would be very simple if the tractive effort of the locomotive or motor car and the resistance of the train were constant at all speeds, and the methods which appear to have heretofore been used for this kind of work are based on the assumption of a constant difference between the tractive force and the resistance through the whole range, or through part of the range [illegible].

Actually this difference, or unbalanced tractive effort, [illegible] as the speed increases, and becomes [illegible] the "balancing speed," or the velocity at which the tractive effort just equals the resistance. [illegible] under a given condition of grade [illegible] practically to [illegible] the balancing speed [illegible] would suggest that correct results [illegible] the initial unbalanced tractive effort [illegible] substituting [illegible]

$$[illegible] \quad (1)$$

$$[illegible] \quad (2)$$

$$[illegible] \quad (3)$$

in which F = the accelerating force

m = the mass of the train

a = the acceleration in feet per second per second

W = the weight of the train in pounds

g = the acceleration due to gravity = 32.16 feet per second per second

v = the velocity in feet per second

t = the time in seconds

s = the distance in feet

But, since the unbalanced tractive effort at the start is much larger than assumed, the speed increases very rapidly at first and very slowly when the balancing speed is approached, with the result that the average speed is much greater than it would be under the conditions substituted for the real ones. Consequently, the distance traveled will not be even approximately correct. A closer approximation can be made by successive calculations for short intervals of time. For example, if intervals of five seconds are chosen, the velocity and distance during the first interval from the start are calculated from equations (3) and (4) [illegible] the unbalanced tractive effort at the velocity [illegible] equation (3) to find a new velocity [illegible] the first interval. The distance [illegible]

$$[illegible]$$

in which [illegible] interval, in fact [illegible] a third interval and [illegible] of these methods [illegible] to which [illegible] method too laborious [illegible] are believed to be typical [illegible] devised for the [illegible]. While

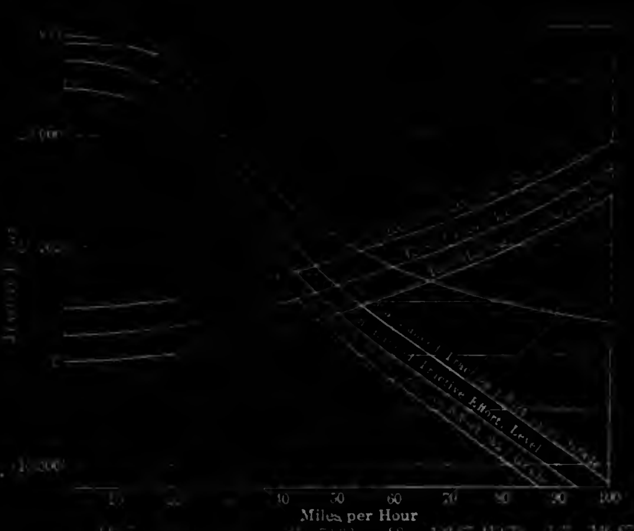


Fig. 1

[illegible] and would prefer to build [illegible] first and to tell afterward what [illegible] wants to know what the results will [illegible] is made. When, therefore, [illegible] an estimate is to be submitted, [illegible] practical phase to any method that enables it to be made [illegible] degree of accuracy and at a reasonable cost. While the data should be determined with the utmost care, the actual work is little else than planimetry and plotting.

First the tractive effort and the train resistance are plotted as shown in Fig. 1. Much has been printed in the technical papers, in books, and in the proceedings of the engineering societies on tractive effort and train resistance, and the engineer should satisfy himself through such sources and his own experience as to the correctness of these curves, for the reliability of the whole work depends upon them. It may be necessary to plot

resistances for other grades as well as those shown. The curve of accelerating force, or unbalanced tractive effort, is, of course, plotted by taking differences between the total tractive effort and the resistance; for example, at 50 miles per hour the tractive effort is 10,500 lbs., the resistance on the 0.2 per cent. grade is 8,900 lbs., and the unbalanced tractive effort is 1,700 lbs. For

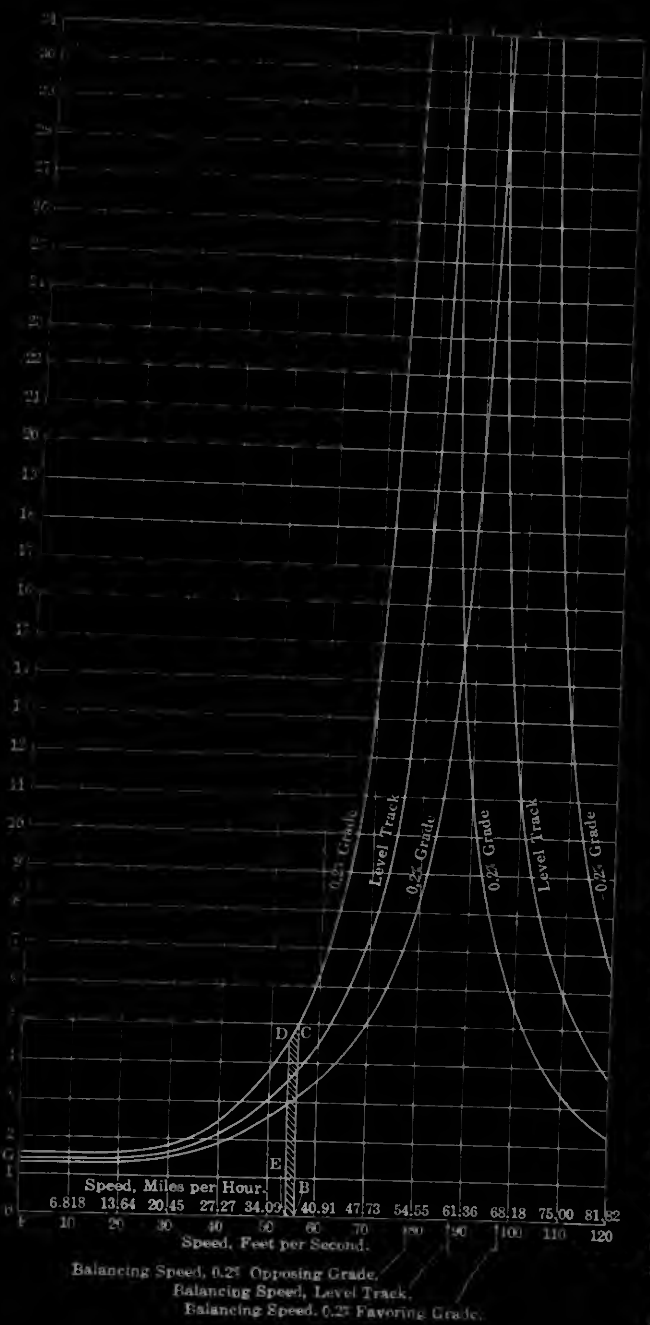


FIG. 2.

any grade the tractive effort and resistance curves cross at the balancing speed, and the curve of unbalanced tractive effort crosses the zero line at the same speed.

In Fig. 2 are plotted values of $\frac{1}{a}$ or $\frac{w}{g f}$ (see equation 1), the value of f being taken from Fig. 1 for each speed plotted. Since the accelerating force is not absorbed in the linear acceleration alone, but must alter the angular velocity of the wheels and axles, an allowance for this extra effort must be made. This can be done by adding to the weight of the train the values of $\frac{g I}{r^2}$ for all the rotating parts, which may be expressed as $\Sigma \frac{g I}{r^2}$, I being the moment of inertia and r the radius of the tread of the wheel. I is, of course, equal to $\frac{\Sigma w \rho^2}{g}$, where w is the weight of an elementary particle of the wheel and ρ its distance from the center. The allowance for the rotating parts may be expected to lie between 2 per cent. and 8 per cent. of the total weight.

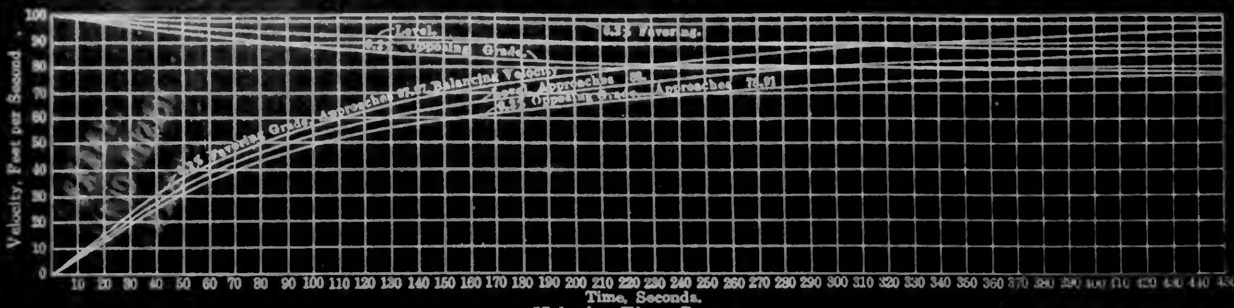
Under favorable circumstances a train may reach a given grade at a speed higher than the balancing speed. It will then be retarded, and the acceleration as well as its reciprocal will have negative values. The curves at the right-hand side of Fig. 2 should strictly, therefore, be inverted and placed below the zero line, so that the complete curve for any grade passes from the positive to the negative values through the infinite value at the balancing speed. The curves are all plotted above the zero line, however, on account of the convenience of the small diagram.

Now let dv represent the small increase in velocity from E to B (Fig. 2), and let dA represent the area of the small strip $B\ C\ D\ E$.

$$dA = \frac{w}{f g}\, dv \text{ (nearly).}$$

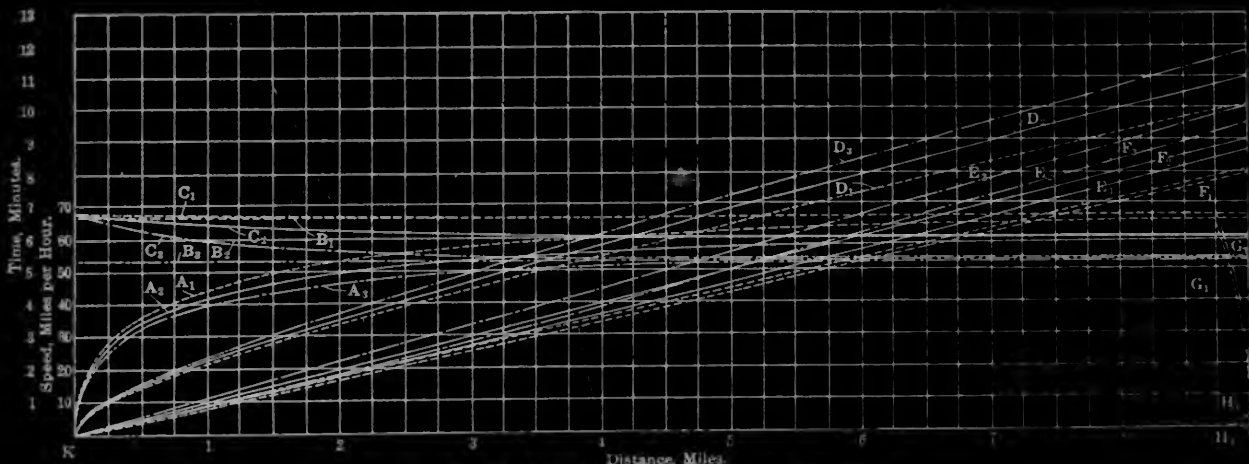
But (equation 2) $a = \frac{f g}{w}$ and a, being the rate of change of speed with reference to the time, is equal to $\frac{dv}{dt}$, in which dt is the short interval of time in which the speed increases from E to B. Then $dA = \frac{1}{a}\, dv = dt$. That is, the area $B\ C\ D\ E$ is equal to the time required for the velocity to increase from E to B, and the whole area $B\ C\ G\ F$ must equal the time required to reach the speed indicated at B from the start. This principle is applied in plotting the velocity-time curves of Fig. 3. For example, the time to plot horizontally at the height of the speed of 30 feet per second is equal to the area under the acceleration-reciprocal curve of Fig. 2 between the zero and 30 ordinates and that for the speed of 50 feet per second is similarly obtained from the area between the zero and 50 ordinates. The planimeter should, of course, be adjusted to the scales and units of measurement adopted, or the results should be multiplied by the proper factor. For the retarded velocity, in this case plotted from that of 100 feet per second, areas are measured to the left from the 100 feet per second ordinate. The problem of the momentum grade is an extreme case of retarded velocity. These speed curves should approach indefinitely the balancing speed indicated in Fig. 1.

Since the distance traveled in a short interval, dt, is equal to $v\,dt$, it follows that the total distance traveled in a given time is equal to the area under the velocity-time curve of Fig. 3. By measuring these areas, therefore, distances are found at which both the time and the speed can be plotted as in Fig. 4. The speed-distance curves should approach the balancing speed indefinitely, and the time-distance curves should approach indefinitely the condition of being straight lines parallel to the inclined straight lines representing the time-distance relation if the train had been traveling all the time at its balancing speed. The vertical distance between these lines represents the time lost in accelerating. For example, if the train passes a given point on a 0.2 per cent. grade at its balancing speed, about 54 miles per hour, it will reach a point seven miles beyond in 7.8 minutes. But if it is started from a stand-still it would require



Velocity-Time Curves.

FIG. 3.



Time-Distance and Speed-Distance Curves.

Subscript "1" and dotted lines indicate 0.2 per cent. favoring grades.
Subscript "2" and full lines indicate level track.
Subscript "3" and broken lines indicate 0.2 per cent. opposing grade.
Curves *A* show speeds from start.
Lines *B* show balancing speeds.
Curves *C* show speeds from 100 ft. per sec., or 68 miles per hour.

Curves *D* show distances from start.
Lines *E* show distances at balancing speed.
Curves *F* show distances from a speed of 100 ft. per second, or 68 miles per hour.
Curves *G* show speeds with brake applied.
Curves *H* show distances with brake applied.

FIG. 4.

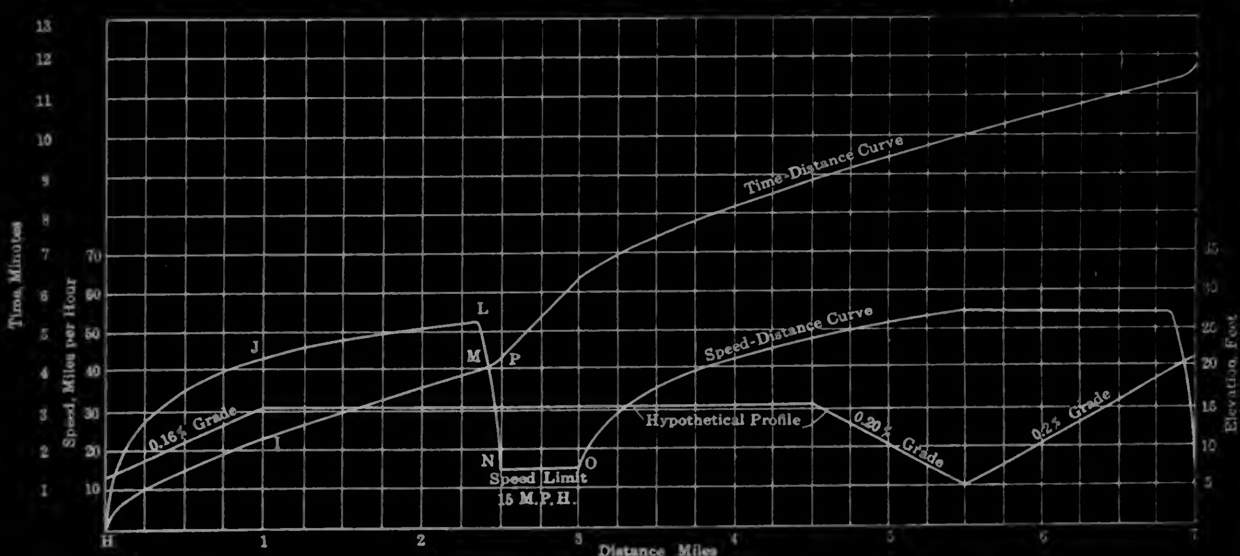


FIG. 5.

about 9.6 minutes to travel those seven miles, and 1.8 minute would have been lost.

The speed and distance curves for the brake can be found in the same way, but the deceleration for the brake is so much nearer constant, and the time when the brake is applied is so short, that the formulas (3) and (4) can be used without serious error.

The final result is to be exhibited in such a diagram as Fig. 5, in which the same scales for time, speed and distance are adopted as in Fig. 4. The grades are compensated, and the profile laid off on tracing cloth. It is assumed that the speed during the latter half of the third mile is to be limited to 15 miles per hour on account of operating conditions. The track starts with a 0.16 per cent. grade. The tracing cloth being placed on Fig. 4 so that *H* and *K* coincide, the time curve *H I* and the speed curve *H J* are drawn, interpolating between the curves

for level track and for 0.2 per cent. in Fig. 4. The cloth is then moved horizontally until *J* falls on the speed curve for level track, and *J L* is traced. Then the cloth is moved vertically until *J* falls on the distance curve for level track, and *J M* is drawn. *N O* is drawn at 15 miles per hour, and *N* is placed so that it falls on the brake curve. *L N* is then drawn to meet the previously drawn speed curve, and the cloth moved vertically until *M* falls on the distance curve for the brake, when *M P* is drawn. The remainder is traced in a similar way.

Although the explanation of the method is somewhat tedious, the actual work is much simpler than accurate calculations. The use of curves makes it unnecessary to plot so many points as would have to be calculated, and the relations of the curves are so apparent that an error would be quickly discovered. Moreover, the diagram of Fig. 4 having once been made, can be applied to any number of miles of the final Fig. 5 diagram.

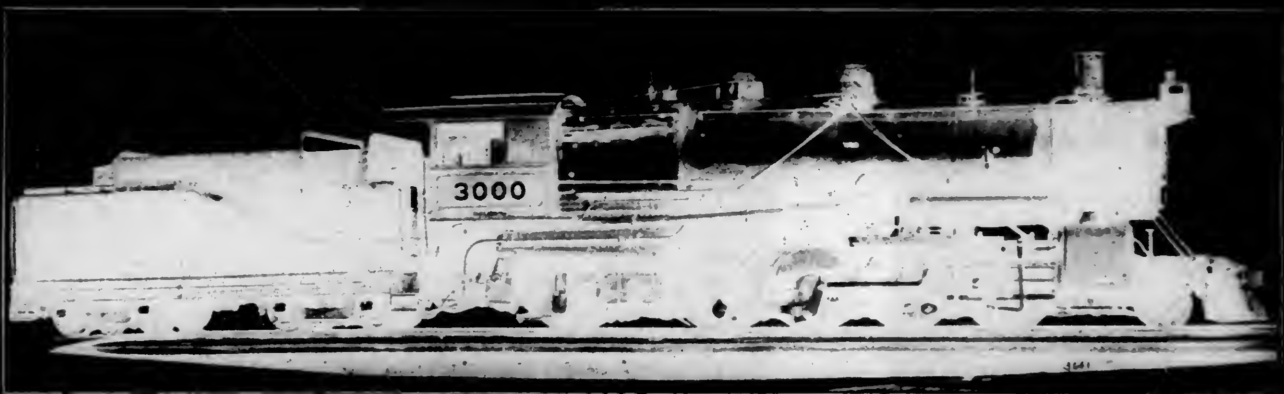
Superheater Locomotives 2-8-2 Type

GREAT NORTHERN RAILWAY

TWENTY LOCOMOTIVES RECENTLY DELIVERED BY THE BALDWIN LOCOMOTIVE WORKS, WHICH HAVE BEEN PUT IN SERVICE ON THE GREAT NORTHERN RAILWAY, ARE AMONG THE MOST POWERFUL OF THE SIMPLE LOCOMOTIVES ON OUR RECORD, BEING PRACTICALLY EQUIVALENT TO THE MALLETS WHICH THAT COMPANY HAS IN ROAD SERVICE.

As our readers are well aware, the past year has shown a great revival of interest and a very general development of the 2-8-2 or Mikado type locomotives for freight service. This design has been continually enlarged and improved, greatly surpassing anything which was considered possible when it was practically abandoned [illegible] years ago [illegible] until comparatively [illegible] was believed [illegible] only by the Mallet type. The [illegible] June, 1910, issue of this journal. They were not fitted with superheaters, although a later order of the 2-6-6-2 type, materially larger in size, were equipped with Emerson superheaters and feed water heaters.

In accordance with the Great Northern Railway's practice, the boiler is of the Belpaire type and [illegible] the crown sheet and outside roof sheets slightly arched [illegible] the mud ring [illegible] width, [illegible]



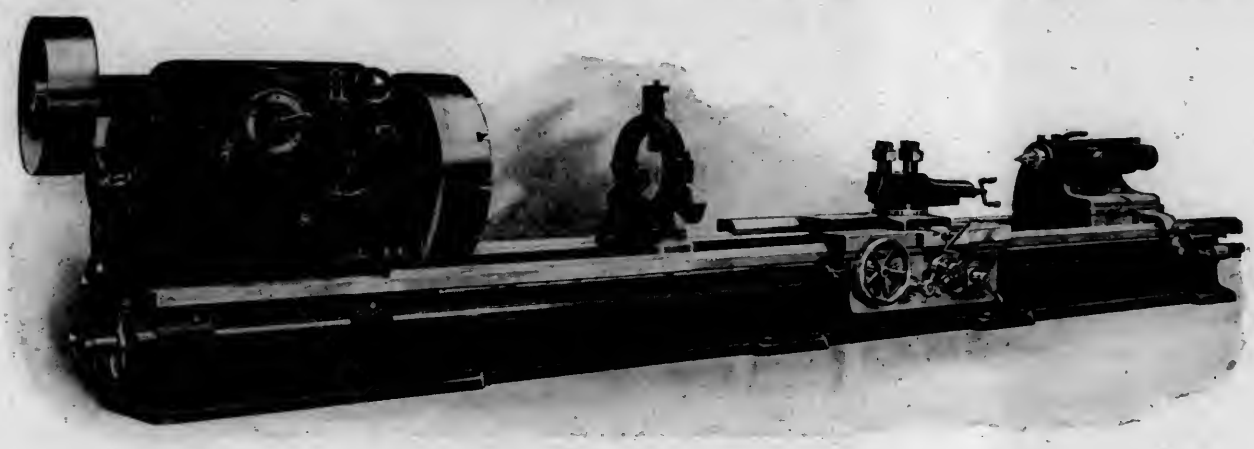
VERY POWERFUL [illegible] LOCOMOTIVE EQUIPPED WITH EMERSON SUPERHEATER.

reason for this renewed lease of life will be found principally in the success of the high degree superheater which has so greatly increased boiler capacity, as to permit a boiler of sufficient capacity per unit of weight to be supported on four coupled drivers without exceeding [illegible] axle loads and enable the locomotive to deliver a very high ratio of its maximum tractive effort at moderately high speeds. In the September issue, on page 346, will be found a discussion of the comparative merits of the consolidation and the Mikado type locomotive, wherein it is pointed out that while the maximum theoretical tractive effort of the Mikado could be attained by the consolidated type, it is the sustained high tractive effort at high speed, which means boiler capacity, that is assured by the former.

On the locomotives illustrated herewith, a boiler 82 in. in diameter at the front ring and 89 in. maximum diameter, having 21 ft. flues, and a grate area of 78.2 sq. ft., has been applied. It is fitted with an Emerson high degree superheater having 1,060 sq. ft. of heating surface and the pressure has been reduced to 170 lbs. This boiler is of practically equivalent size, but is of greater capacity than the one applied to the 2-6-6-2 type locomotives, of which there are 45 in service on this road. These locomotives were illustrated and described on page 213 of the

at the sides and [illegible] in the back [illegible] illustrations will be seen the arrangement and [illegible] 5[illegible] in. tubes enclosing the superheater elements [illegible] thirty of them. It will be remembered that the Emerson superheater employs headers somewhat similar in shape and location to the ordinary steam pipes. An improvement has been made in this application, in that the saturated and superheated steam chambers are in separate castings, which are bolted together, leaving an air space between. The bolt holes are sufficiently large to permit of movement due to the different rates of expansion of the two sections. These headers connect to the steam passages in the saddle in the usual manner, but [illegible] connects the two passages below the header connection, thus permitting the equalization of pressure and allowing each cylinder to draw on both superheater sections for its supply. The cylinders are 28 in. x 32 in., the walls being made thick enough to permit boring to 29 in. in diameter if desired. These cylinders are somewhat larger than the ones applied to the Illinois Central Mikado type, illustrated in the September issue, but in other respects the two designs are very similar. The Illinois Central engine having the Schmidt superheater of practically the same size is the Emerson applied here.

A novelty is found in this design in connection with the ash



BRIDGEPORT 42-INCH GEARED HEAD ENGINE LATHE—BRIDGEPORT MACHINE TOOL WORKS.

the top of the plain table is 32 in. The sleeve has ball bearing thrust collars using ¾ in. balls, which are warranted to stand the most severe service continuously without breakage of the balls or crushing of the collars. The change gear mechanism, located at the side of the spindle, provides three changes of feed (.007, .016, and .032 to a revolution), any one of which is instantly available by shifting the lever over the gear box. The box works on the "pull pin" principle as distinguished from the sliding key and may be thrown in or out while the drill is cutting without danger of damaging the mechanism. In addition to the power feed the machine is provided with a hand feed through worm and worm wheel and a quick return. The feeds are provided with automatic stops, which are adjustable and knock off the feed at any desired point. A safety friction device is also provided for the feed to prevent damage in case of accident.

Eight spindle speeds are provided by the four step cone pulleys and the back gears; with the counter shaft running at 350 revolutions per minute and the back gears in, the spindle speeds are 23, 30, 38 and 50 r. p. m.; with the back gears out the speeds are 80, 103, 133 and 170 r. p. m.

The table is fitted to the column by a square locked slide and is clamped by straps. Additional support is given underneath by a 3 in. square thread elevating screw, which acts as a solid jack in line with the spindle when the machine is in operation. The table is provided with an oil groove and has a working surface of 26 x 34 in. These machines are manufactured by The Foote-Burt Company, Cleveland, Ohio.

42-INCH GEARED HEAD ENGINE LATHE.

The 42-inch geared head engine lathe, illustrated herewith, is a recent design of the Bridgeport Machine Tool Works, Rochester, N. Y. It has been designed to meet the severest requirements and is provided with a mechanical means for quickly changing the spindle speed. Power is applied to a constant speed pulley and fifteen spindle speeds, in geometrical progression, are obtained through a speed variator. The levers for operating this device are conveniently located, as shown. All of the gears in the head run in oil. The gearing is proportioned to give from 2.26 to 110.8 revolutions of the driving pulley to one of the face plate. The pulling power on a 42 in. diameter is said to be 25,000 lbs. or about four times that of an ordinary cone driven lathe.

The lathe may be driven by a motor of from 25 to 40 h.p., according to the requirements. The motor is mounted on the head stock and the belt pulley is replaced by a silent chain sprocket, or a raw hide gear, as desired. A constant speed motor may be used, although the makers recommend one having a speed variation of 1½ or 2 to 1. With a variable speed motor the controller is operated from the carriage through a splined shaft. The bed is of a substantial and rigid design and has a longitudinal rib with a cast rack, with which a pawl at the back of the tail stock engages. This forms a positive stop for the tail stop, which is of considerable advantage when the lathe is engaged on heavy work. The 42-inch lathe with a 26-foot bed weighs 36,000 lbs. The same type of lathe is furnished with 26, 32, 36, 42 and 48 inches swing.

ROUND HOUSE WORK REPORTS.

To the Editor:

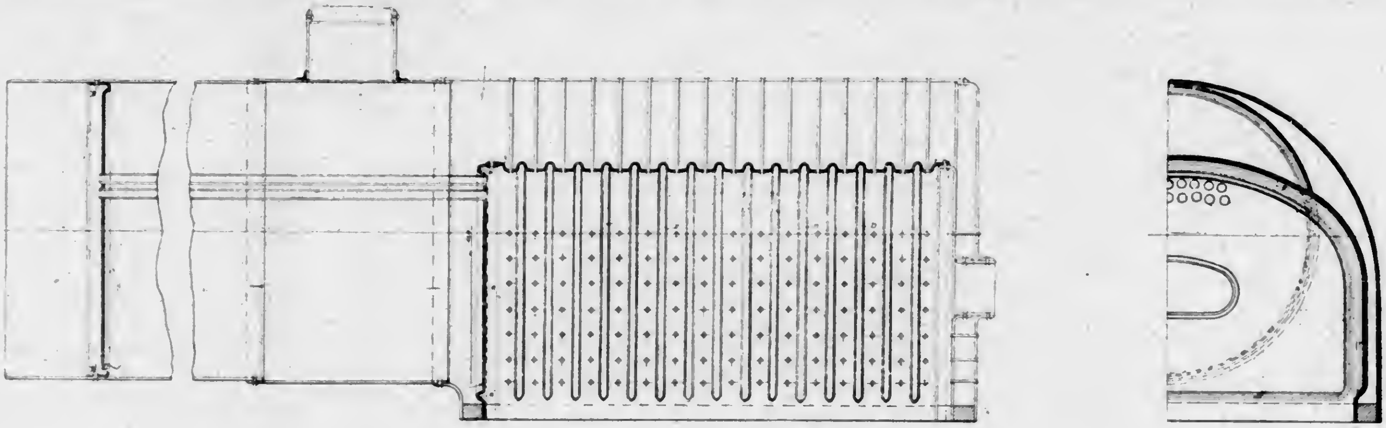
I would like to gain some information as to the best methods of handling roundhouse work reports. Our method is to keep the original report, which is made on a suitable form by the engineer, in the work book and supply each man with a small slip showing the work he is expected to do. This is not entirely satisfactory for two reasons: first, because of the large amount of clerical work involved, and second, while a record of the work each man is expected to do is in the work book we do not require his signature to the effect that he has done the work, which is important. The work slips are made on small pieces of plain paper and show the number of the engine, the work which is to be done and the name of the man who is to do it. It has been suggested that the workman might sign his name on the back of the slip after he had completed the work and turn it in, but as these slips are quite small it would be practically impossible to save and file them all, and even then it is doubtful if they would be of any value in a court of law.

We could give out the original work reports and have the men doing the work sign them on the back, but as it is oftimes difficult to decipher tnese when clean, it would be practically impossible to read them after they had been handled by several workmen. Do you know of any method in use which would overcome these difficulties?

Division Foreman.

[Editor's Note: We shall be pleased to hear from any of our readers who know of a more satisfactory method.]

Apprenticeship Exhibit, Railroad Mechanical Conventions. —A novel feature of the Atlantic City conventions will be the exhibit of the committee on apprenticeship. It is expected that the railroads operating apprentice schools will send models, drawings and photographs to show in a comprehensive manner the rapid advancement which is being made in this phase of railroad activity. The following roads have thus far consented to exhibit: Central Railroad of N. J., Grand Trunk, Santa Fé and New York Central Lines. The members of the committee are C. W. Cross, superintendent of apprentices, New York Central Lines, chairman; G. M. Basford, assistant to president, American Locomotive Company; W. D. Robb, superintendent motive power, Grand Trunk; A. W. Gibbs, general superintendent motive power, Pennsylvania Railroad; B. P. Flory, mechanical engineer, Central Railroad of New Jersey; John Tonge, master mechanic, Minneapolis & St. Louis; F. W. Thomas, superintendent of apprentices, Santa Fé.



WOOD'S IMPROVED TYPE OF LOCOMOTIVE BOILER.

ticularly when made of high speed steel, plays a very important part. A cutter made of this material with a large number of teeth, has a considerably shorter life than one with fewer but deeper teeth. In a certain case, two milling cutters, one with 16 teeth, and one with 32 teeth, had been made. The one with the coarser teeth, of helical shape, would finish an article with as good a finish as the one with the finer pitched teeth, but the cost of making the coarse-pitched cutter was 35 per cent. less than the cost of making the one with the fine-pitched teeth, and the life of the coarse pitched cutter was four or five times as long as that of the other.—*Machinery.*

AN IMPROVED LOCOMOTIVE BOILER.

An attendant at any of the railway mechanical conventions cannot help but be impressed by the lively interest which is taken in any papers dealing with improvements or suggested improvements of locomotive boilers. This is always a live and interesting subject and in spite of the care and attention that has been given it, during past years, dealing with both boiler construction and purification of feed water, there is no doubt but what leaky boilers are the source of more trouble and delay than any other feature of the locomotive.

Realizing these conditions and after studying the subject thoroughly for a long while, Mr. William H. Wood, an engineer of Media, Pa., has come to the conclusion that the trouble is due very largely to the construction of the boiler, principally on account of there being, in the ordinary locomotive boiler, practically no provision for taking care of the contraction and expansion, either in the fire-box or the flues. Following this decision he has designed improvements for locomotive boilers which he believes will overcome this difficulty and the accompanying illustrations show a boiler fitted as he suggests.

It will be noticed that the difference between this boiler and one of the ordinary type consist of a special form of flange for the front and back tube sheet, which will allow greater flexibility for taking care of the expansion of the flues, thus preventing the working of the flue in the sheet with consequent leaking. In addition, the fire-box sheets are made of steel pressed with vertical recesses equally divided in the length of the box, somewhat similar to the corrugations used in Fox and Morrison furnaces in marine work. In this manner the expansion of the crown and side sheets of the fire-box is equally distributed throughout the length of the sheet, being taken up by the flexibility of the flanged recesses instead of being concentrated at the edges as is the case with the plain sheets.

The illustration shows this fire-box as applied to a Wooten type, but the same principle will hold for soft coal fire-box. It might also be mentioned that, while the illustration shows the pressed steel fire-box used with the flexible flanges on the tube sheets, this type of flange can be used with the ordinary straight fire-box sheets, depending on the flexibility of the joint between the back tube sheet and the firebox for taking up the expansion.

It is believed by Mr. Wood that this type of boiler will be found to have the following advantages:

It will permit the flues to contract and expand without being loosened in the sheet.

It will provide for a vertical expansion of the tube sheet.

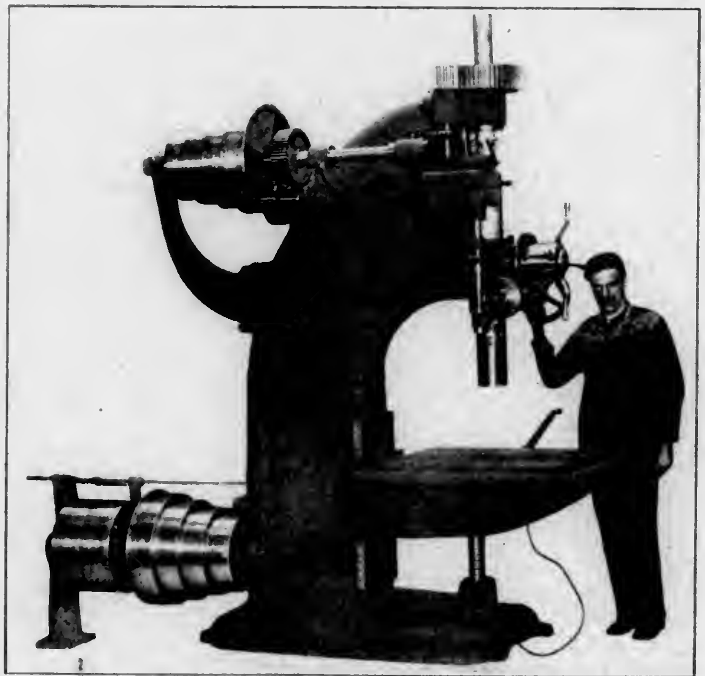
The heating surface in the fire-box, which is increased about 30 per cent., will result in an increased efficiency in the boiler.

A fire-box flanged in this form is necessarily much stronger and hence will need less staying.

Since a contraction and expansion of the box is equally divided between each staybolt that there will be much less total bending action of the staybolts at the ends and corners of the sheets and hence fewer broken staybolts.

HIGH DUTY DRILL.

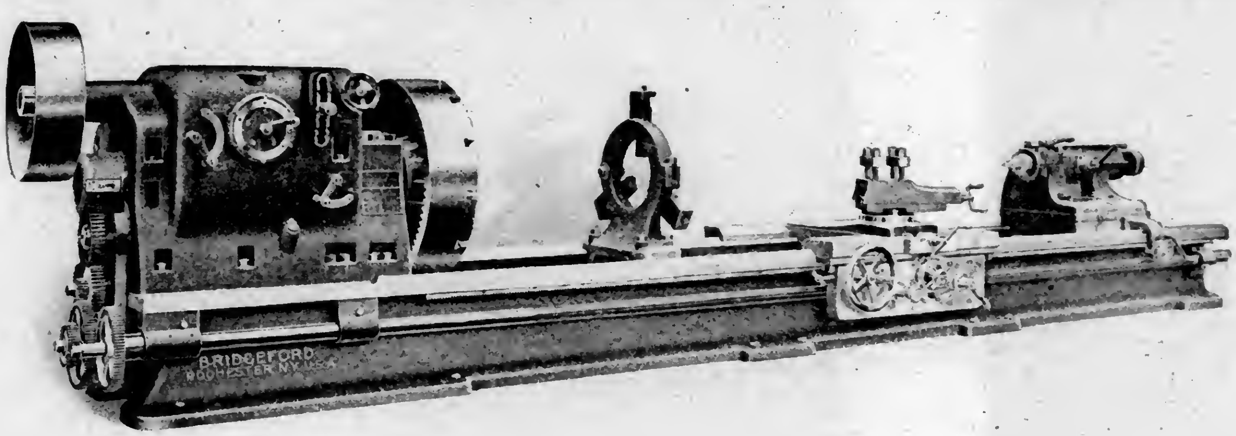
The Foote-Burt high duty drill shown in the photo is guaranteed to drive a $3\frac{1}{2}$ in. high speed steel drill to its full cutting capacity in steel. The design and weight of the machine are such as to make it very rigid, there being no deflection between the point of the spindle and the table under the most severe service, thus making it possible to use the drills to their highest point of efficiency and without danger of breakage. These machines are



FOOTE-BURT HIGH DUTY DRILL.

made with two depths of throat, capable of drilling to the centers of 44 and 60 in. circles. They may be furnished with either a straight drive, as shown, or a right angle drive, and with either a compound or a plain table.

The spindle is $3\frac{1}{2}$ in. in diameter in the sleeve, which is 23 in. long, and the maximum distance of the nose of the spindle from



BRIDGEPORT 42-INCH GEARED HEAD ENGINE LATHE—BRIDGEPORT MACHINE TOOL WORKS.

the top of the plain table is 32 in. The sleeve has ball bearing thrust collars using 3/4 in. balls, which are warranted to stand the most severe service continuously without breakage of the balls or crushing of the collars. The change gear mechanism, located at the side of the spindle, provides three changes of feed (.007, .016, and .032 to a revolution), any one of which is instantly available by shifting the lever over the gear box. The box works on the "pull pin" principle as distinguished from the sliding key and may be thrown in or out while the drill is cutting without danger of damaging the mechanism. In addition to the power feed the machine is provided with a hand feed through worm and worm wheel and a quick return. The feeds are provided with automatic stops, which are adjustable and knock off the feed at any desired point. A safety friction device is also provided for the feed to prevent damage in case of accident.

Eight spindle speeds are provided by the four step cone pulleys and the back gears; with the counter shaft running at 350 revolutions per minute and the back gears in, the spindle speeds are 23, 30, 38 and 50 r. p. m.; with the back gears out the speeds are 80, 103, 133 and 170 r. p. m.

The table is fitted to the column by a square locked slide and is clamped by straps. Additional support is given underneath by a 3 in. square thread elevating screw, which acts as a solid jack in line with the spindle when the machine is in operation. The table is provided with an oil groove and has a working surface of 26 x 34 in. These machines are manufactured by The Foote-Burt Company, Cleveland, Ohio.

42-INCH GEARED HEAD ENGINE LATHE.

The 42-inch geared head engine lathe, illustrated herewith, is a recent design of the Bridgeport Machine Tool Works, Rochester, N. Y. It has been designed to meet the severest requirements and is provided with a mechanical means for quickly changing the spindle speed. Power is applied to a constant speed pulley and fifteen spindle speeds, in geometrical progression, are obtained through a speed variator. The levers for operating this device are conveniently located, as shown. All of the gears in the head run in oil. The gearing is proportioned to give from 20 to 110.8 revolutions of the driving pulley to one of the face plate. The pulling power on a 42 in. diameter is said to be ,000 lbs. or about four times that of an ordinary cone driven lathe.

The lathe may be driven by a motor of from 25 to 40 h.p., according to the requirements. The motor is mounted on the head stock and the belt pulley is replaced by a silent chain sprocket, or a raw hide gear, as desired. A constant speed motor may be used, although the makers recommend one having a speed variation of 1½ or 2 to 1. With a variable speed motor the controller is operated from the carriage through a splined shaft. The bed is of a substantial and rigid design and has a longitudinal rib with a cast rack, with which a pawl at the back of the tail stock engages. This forms a positive stop for the tail stop, which is of considerable advantage when the lathe is engaged on heavy work. The 42-inch lathe, with a 26-foot bed weighs 36,000 lbs. The same type of lathe is furnished with 26, 32, 36, 42 and 48 inches swing.

ROUND HOUSE WORK REPORTS.

To the Editor:

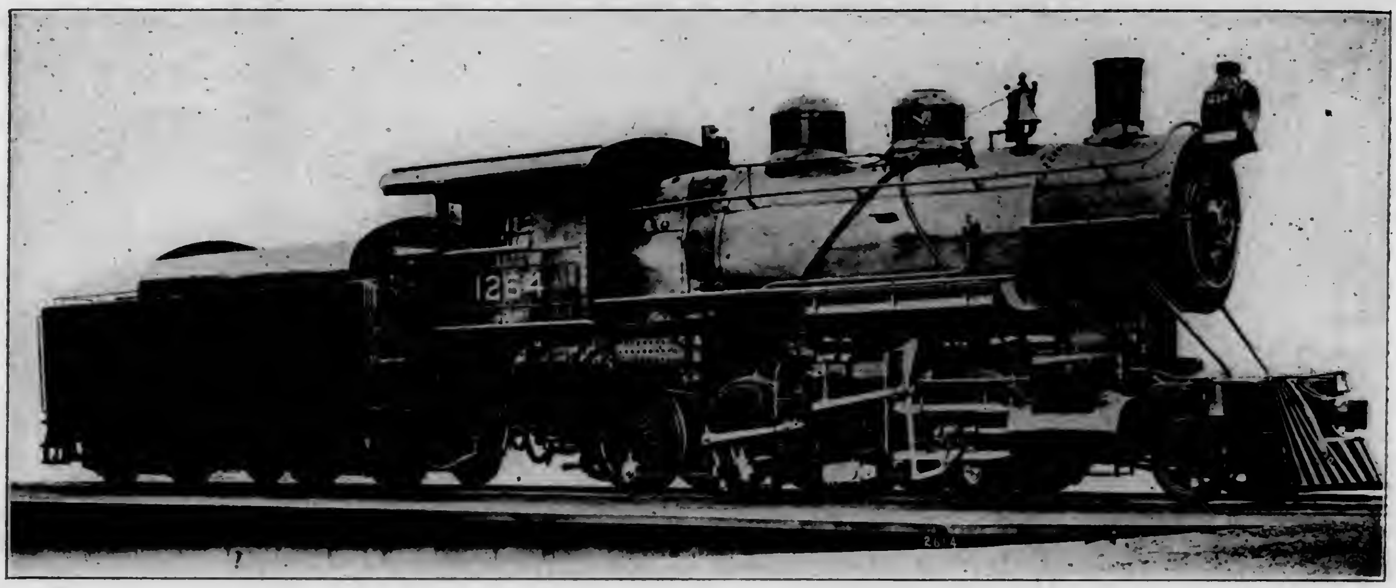
I would like to gain some information as to the best methods of handling roundhouse work reports. Our method is to keep the original report, which is made on a suitable form by the engineer, in the work book and supply each man with a small slip showing the work he is expected to do. This is not entirely satisfactory for two reasons: first, because of the large amount of clerical work involved, and second, while a record of the work each man is expected to do is in the work book we do not require his signature to the effect that he has done the work, which is important. The work slips are made on small pieces of plain paper and show the number of the engine, the work which is to be done and the name of the man who is to do it. It has been suggested that the workman might sign his name on the back of the slip after he had completed the work and turn it in, but as these slips are quite small it would be practically impossible to save and file them all, and even then it is doubtful if they would be of any value in a court of law.

We could give out the original work reports and have the men doing the work sign them on the back, but as it is oftimes difficult to decipher these when clean, it would be practically impossible to read them after they had been handled by several workmen. Do you know of any method in use which would overcome these difficulties?

Division Foreman.

[Editor's Note: We shall be pleased to hear from any of our readers who know of a more satisfactory method.]

Apprenticeship Exhibit, Railroad Mechanical Conventions.—A novel feature of the Atlantic City conventions will be the exhibit of the committee on apprenticeship. It is expected that the railroads operating apprentice schools will send models, drawings and photographs to show in a comprehensive manner the rapid advancement which is being made in this phase of railroad activity. The following roads have thus far consented to exhibit: Central Railroad of N. J., Grand Trunk, Santa Fé and New York Central Lines. The members of the committee are C. W. Cross, superintendent of apprentices, New York Central Lines, chairman; G. M. Basford, assistant to president, American Locomotive Company; W. D. Robb, superintendent motive power, Grand Trunk; A. W. Gibbs, general superintendent motive power, Pennsylvania Railroad; B. P. Flory, mechanical engineer, Central Railroad of New Jersey; John Tonge, master mechanic, Minneapolis & St. Louis; F. W. Thomas, superintendent of apprentices, Santa Fé.



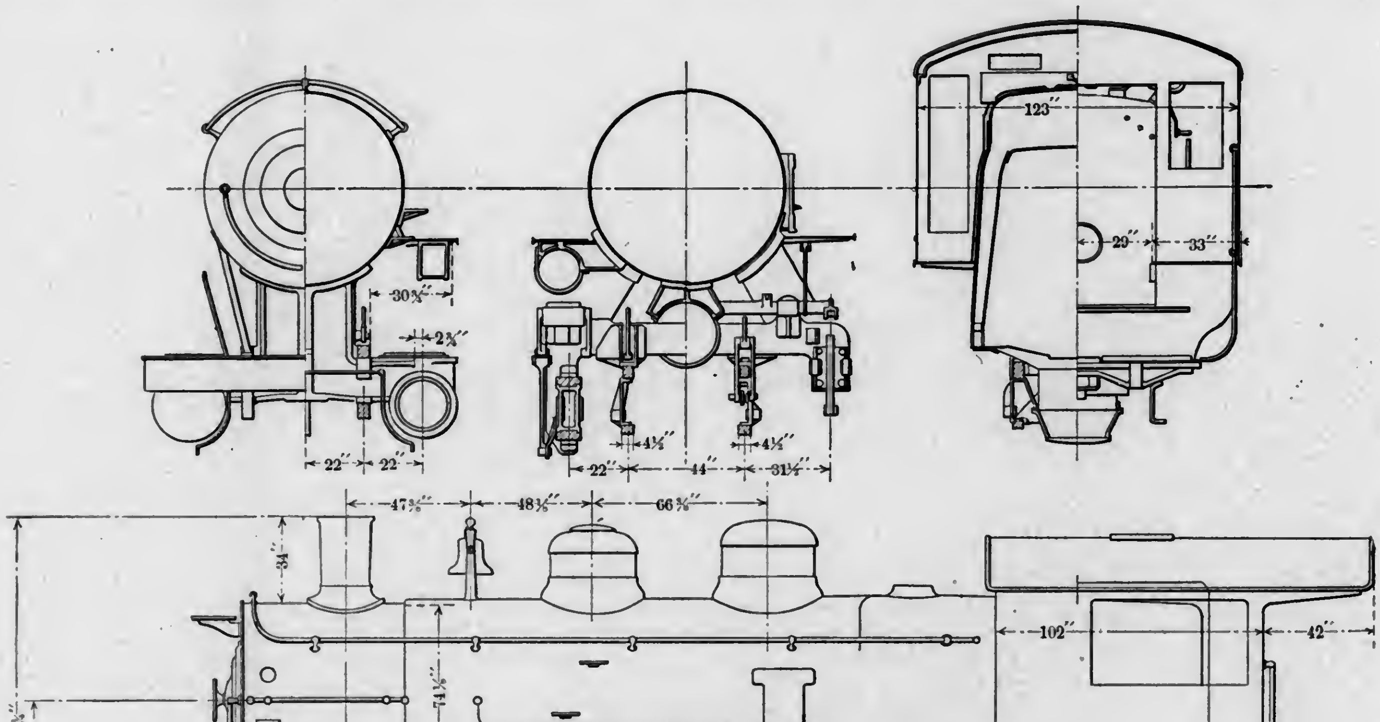
HEAVY CONSOLIDATION LOCOMOTIVE—GREAT NORTHERN RAILWAY.

CONSOLIDATION TYPE LOCOMOTIVE.

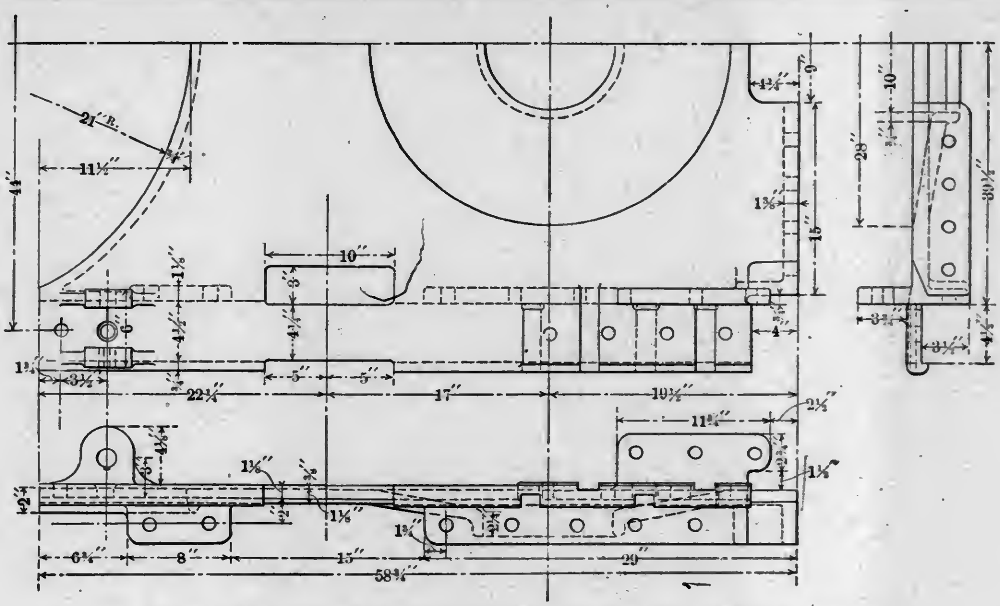
GREAT NORTHERN RAILWAY.

The Baldwin Locomotive Works has recently completed an order of 50 locomotives of the consolidation type for the Great Northern Railway. These engines are known in the road's classification as class F 8 and the general design was worked out in accordance with drawings furnished by the railway company. A somewhat unusual arrangement of Walschaert valve gear which was designed by the builders has been applied.

These locomotives have a total weight of 210,350 lbs., of which 188,250, or about 90 per cent., is on drivers. The cylinders, 20 x 32 in., with 55 in. drivers and 210 lbs. steam pressure give a theoretical tractive effort of 41,540 lbs. This gives a factor of adhesion of 4.53. The boiler is of the Belpaire type, conforming with the standard practice on this road. It has a vertical throat and back head with the crown and roof sheets slop-



SECTIONS AND ELEVATION OF HEAVY CONSOLIDATION LOCOMOTIVE—GREAT NORTHERN RAILWAY.



DETAILS OF FRAME STIFFENING CASTING—GREAT NORTHERN 2-8-0 LOCOMOTIVE.

ing somewhat toward the rear. These sheets are also slightly arched transversely. The water spaces at the mud ring are narrow, measuring but 4 in. for the front and 3½ in. on the sides and back. The barrel of the boiler is built up of two rings, each having a butt jointed sextuple riveted seam on the top center line. These seams are welded under the dome flange and at the ends. The boiler is amply provided with means for washing out, which include two 6 in. hand holes in the bottom of the barrel. It contains 331—2 in. tubes 14 ft. 8 in. long, giving a tube heating surface of 2,523.5 sq. ft. Seven and one-half per cent. of the total heating surface is located in the firebox. The grate area of 59 sq. ft. is larger than is commonly used with this amount of heating surface, and will allow the use of a very low grade of fuel.

The design of Walschaert valve gear is based upon the fact that balanced slide valves are used and it was necessary to place the center of the valve stem 2¾ in. inside the center of the cylinders. This compelled the use of a rocker arm which is supported by the guide yoke. The links are carried by a special support, which spans the frames just back of the second pair of drivers, and is stiffened by a plate extending outside of the driving wheels to the guide yoke, and also by large cast iron knees, fastening it to the frame. This brace also supports the reverse shaft bearing, the arrangement being as shown in the general elevation of the locomotive.

The main frames are of cast steel 4½ in. wide, with two wrought iron front rails, which span the cylinder casting. They are securely tied together at the front and back by cast steel foot plates and in addition are braced by a substantial steel casting located just back of the cylinder saddle. This casting and the front section of the frames are shown in one of the illustrations. It is unusually broad and extends back beyond the first pedestal. Lugs are provided to which the spring hanger is connected and the casting is double keyed and securely bolted to both the main frame and the upper front rail.

The tender trucks are of the pedestal type with equalizing beams over the boxes and semi-elliptical springs. The wheels have cast steel plate centers and the cast steel bolsters are set as low as possible in order to keep down the center of gravity.

The general dimensions, weights and ratios of these locomotives are given in the following table:

GENERAL DATA.

Gauge	4 ft. 8½ in.
Service	Freight
Fuel	Bit. Coal
Tractive effort	41,540 lbs.
Weight in working order	210,350 lbs.
Weight on drivers	188,250 lbs.
Weight on leading truck	22,100 lbs.
Weight of engine and tender in working order	358,000 lbs.
Wheel base, driving	16 ft.
Wheel base, total	24 ft. 3 in.
Wheel base, engine and tender	54 ft. 7 in.

RATIOS.

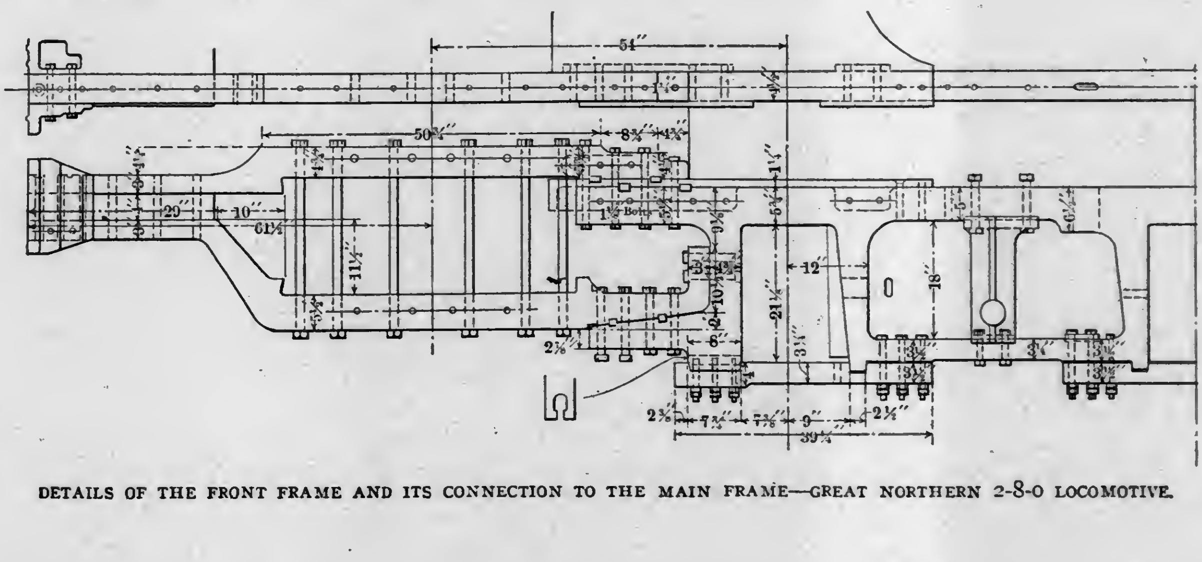
Weight on drivers ÷ tractive effort	4.53
Total weight ÷ tractive effort	5.05
Tractive effort × diam. drivers ÷ heating surface	840.00
Total heating surface ÷ grate area	46.20
Firebox heating surface ÷ total heating surface, %	7.50
Weight on drivers ÷ total heating surface	69.50
Total weight ÷ total heating surface	77.00
Volume both cylinders, cu. ft.	11.70
Total heating surface ÷ vol. cylinders	233.00
Grate area ÷ vol. cylinders	5.05

CYLINDERS.

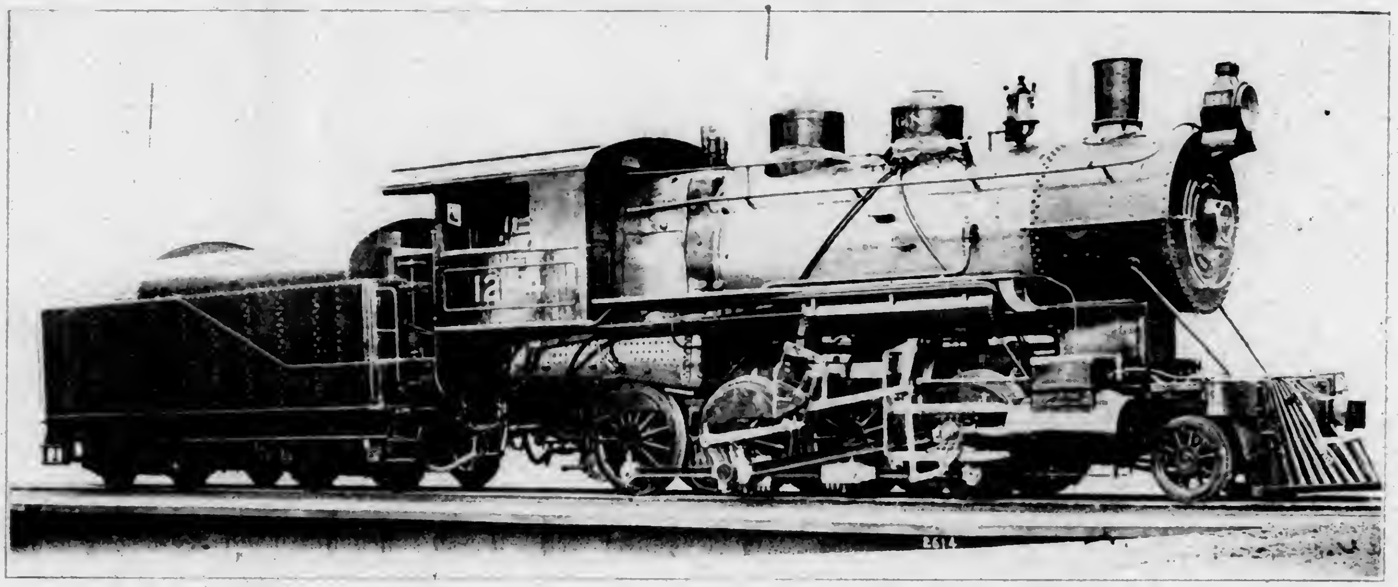
Kind	Simple
Diameter and stroke	20 × 32 in.

VALVES.

Kind	Bal. slide
Greatest travel	6 in.
Outside lap	1 in.



DETAILS OF THE FRONT FRAME AND ITS CONNECTION TO THE MAIN FRAME—GREAT NORTHERN 2-8-0 LOCOMOTIVE.



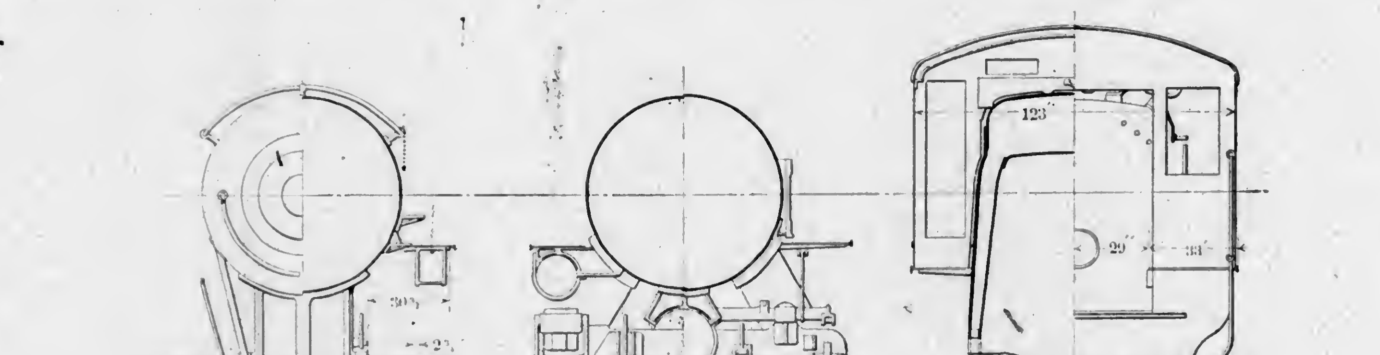
HEAVY CONSOLIDATION LOCOMOTIVE—GREAT NORTHERN RAILWAY.

CONSOLIDATION TYPE LOCOMOTIVE.

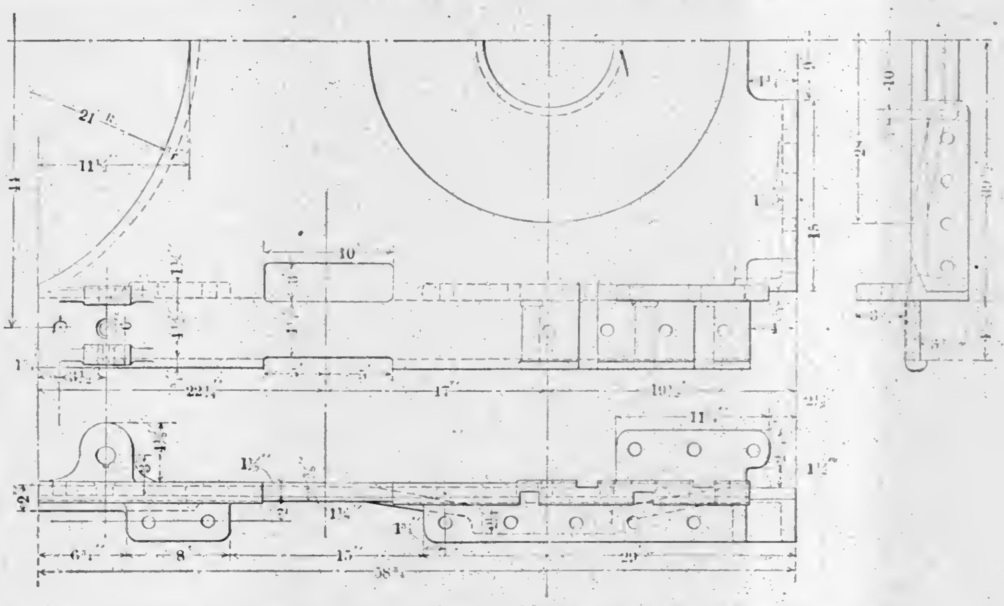
GREAT NORTHERN RAILWAY.

The Baldwin Locomotive Works has recently completed an order of 50 locomotives of the consolidation type for the Great Northern Railway. These engines are known in the road's classification as class F 8 and the general design was worked out in accordance with drawings furnished by the railway company. A somewhat unusual arrangement of Walschaert valve gear which was designed by the builders has been applied.

These locomotives have a total weight of 210,350 lbs., of which 188,250, or about 90 per cent., is on drivers. The cylinders, 20 x 32 in., with 55 in. drivers and 210 lbs. steam pressure give a theoretical tractive effort of 41,540 lbs. This gives a factor of adhesion of 4.53. The boiler is of the Belpaire type, conforming with the standard practice on this road. It has a vertical throat and back head with the crown and roof sheets slop-



SECTIONS AND ELEVATION OF HEAVY CONSOLIDATION LOCOMOTIVE—GREAT NORTHERN RAILWAY.



DETAILS OF FRAME STIFFENING CASTING—GREAT NORTHERN 2-8-0 LOCOMOTIVE.

ing somewhat toward the rear. These sheets are also slightly arched transversely. The water spaces at the mud ring are narrow, measuring but 4 in. for the front and 3½ in. on the sides and back. The barrel of the boiler is built up of two rings, each having a butt jointed sextuple riveted seam on the top center line. These seams are welded under the dome flange and at the ends. The boiler is amply provided with means for washing out, which include two 6 in. hand holes in the bottom of the barrel. It contains 331—2 in. tubes 14 ft. 8 in. long, giving a tube heating surface of 2,523.5 sq. ft. Seven and one-half per cent. of the total heating surface is located in the firebox. The grate area of 59 sq. ft. is larger than is commonly used with this amount of heating surface, and will allow the use of a very low grade of fuel.

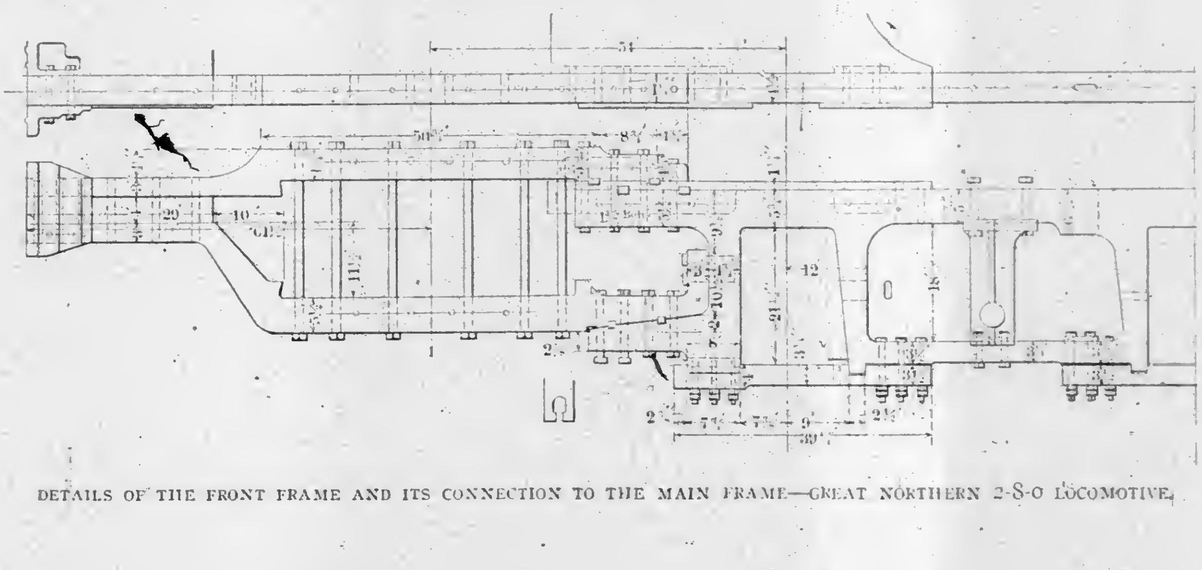
The design of Walschaert valve gear is based upon the fact that balanced slide valves are used and it was necessary to place the center of the valve stem 2¾ in. inside the center of the cylinders. This compelled the use of a rocker arm which is supported by the guide yoke. The links are carried by a special support, which spans the frames just back of the second pair of drivers, and is stiffened by a plate extending outside of the driving wheels to the guide yoke, and also by large cast iron knees, fastening it to the frame. This brace also supports the reverse shaft bearing, the arrangement being as shown in the general elevation of the locomotive.

The main frames are of cast steel 4½ in. wide, with two wrought iron front rails, which span the cylinder casting. They are securely tied together at the front and back by cast steel foot plates and in addition are braced by a substantial steel casting located just back of the cylinder saddle. This casting and the front section of the frames are shown in one of the illustrations. It is unusually broad and extends back beyond the first pedestal. Lugs are provided to which the spring hanger is connected and the casting is double keyed and securely bolted to both the main frame and the upper front rail.

The tender trucks are of the pedestal type with equalizing beams over the boxes and semi-elliptical springs. The wheels have cast steel plate centers and the cast steel bolsters are set as low as possible in order to keep down the center of gravity.

The general dimensions, weights and ratios of these locomotives are given in the following table:

GENERAL DATA.	
Gauge	4 ft. 8½ in.
Service	Freight
Fuel	Bit. Coal
Tractive effort	41,540 lbs.
Weight in working order	210,350 lbs.
Weight on drivers	188,250 lbs.
Weight on leading truck	22,100 lbs.
Weight of engine and tender in working order	358,000 lbs.
Wheel base, driving	16 ft.
Wheel base, total	24 ft. 3 in.
Wheel base, engine and tender	54 ft. 7 in.
RATIOS.	
Weight on drivers ÷ tractive effort	4.53
Total weight ÷ tractive effort	5.05
Tractive effort × diam. drivers ÷ heating surface	810.00
Total heating surface ÷ grate area	46.20
Firebox heating surface ÷ total heating surface, %	7.50
Weight on drivers ÷ total heating surface	69.50
Total weight ÷ total heating surface	77.00
Volume both cylinders, cu. ft.	11.70
Total heating surface ÷ vol. cylinders	233.00
Grate area ÷ vol. cylinders	5.05
CYLINDERS.	
Kind	Simple
Diameter and stroke	20 × 32 in.
VALVES.	
Kind	Bal. slide
Greatest travel	6 in.
Outside lap	1 in.



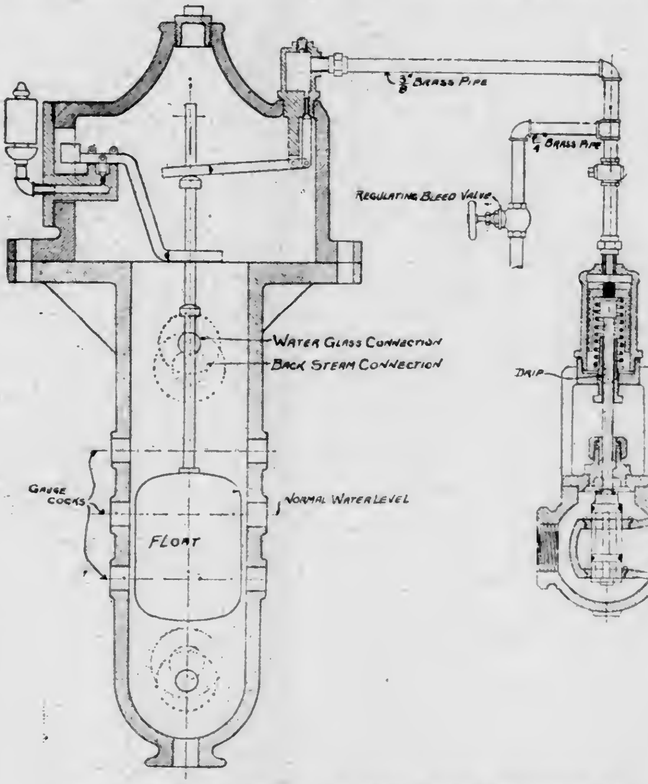
DETAILS OF THE FRONT FRAME AND ITS CONNECTION TO THE MAIN FRAME—GREAT NORTHERN 2-8-0 LOCOMOTIVE.

Inside clearance	0 in.
Lead, constant	3/16 in.
WHEELS.	
Driving, diameter over tires	55 in.
Driving, thickness of tires	3½ in.
Driving journals, diameter and length	9 × 12 in.
Engine truck wheels, diameter	33 in.
Engine truck journals	6 × 12 in.
BOILER.	
Style	Belpaire
Working pressure	210 lbs.
Outside diameter of first ring	74⅛ in.
Firebox, length and width	118 × 72¼ in.
Firebox plates, thickness	⅜ and ⅝ in.
Firebox, water space	F-4 in., S & B-3½ in.
Tubes, number and outside diameter	331—2 in.
Tubes, length	14 ft. 8 in.
Heating surface, tubes	2,523.5 sq. ft.
Heating surface, firebox	204.0 sq. ft.
Heating surface, total	2,727.5 sq. ft.
Grate area	59 sq. ft.
Smokestack, height above rail	15 ft. 5¾ in.
Center of boiler above rail	9 ft. 6 1/16 in.
TENDER.	
Tank	Waterbottom
Frame	12 in. channels
Wheels, diameter	36 in.
Journals, diameter and length	5½ × 10 in.
Water capacity	8,000 gals.
Coal capacity	13 tons

BOILER FEED WATER REGULATOR.

A new type of feed water regulator, simple in construction and reliable in action, which can be applied to any type of stationary boiler, has been designed and is being manufactured by the Golden-Anderson Valve Specialty Company, Fulton Building, Pittsburg, Pa.

This device is called the Gould Safety Continuous feed water regulator and includes a specially designed water column connected by a brass pipe to a controlling valve placed in the feed line of the boiler. The water column is cast iron and contains a copper float which carries a vertical rod fitted with two collars. By adjustment of these collars the water can be carried at any



GOULD SAFETY CONTINUOUS FEED WATER REGULATOR.

desired point in the boiler and the level can be maintained with a very small variation. When the water rises the upper collar on the rod comes into contact with a lever, which opens a small valve, permitting steam pressure to pass through the brass piping to the top of the piston forming part of the controlling valve in the feed line. This piston is then partially or wholly forced downward cutting off the supply to the boiler. When the water recedes the steam valve closes and the pressure in the pipe is gradually dissipated through the regulating bleed valve and the spring beneath the piston forces it up and permits the water supply to again enter the boiler.

The valve in the water end of the feed controlling valve is of the balanced slide valve type, so constructed that any amount of back pressure in the feed line will have no effect in overcoming the steam pressure on top of the small piston. The bleed valve is capable of very close adjustment and can be so adjusted as to make the regulator hold the water level with a very slight variation.

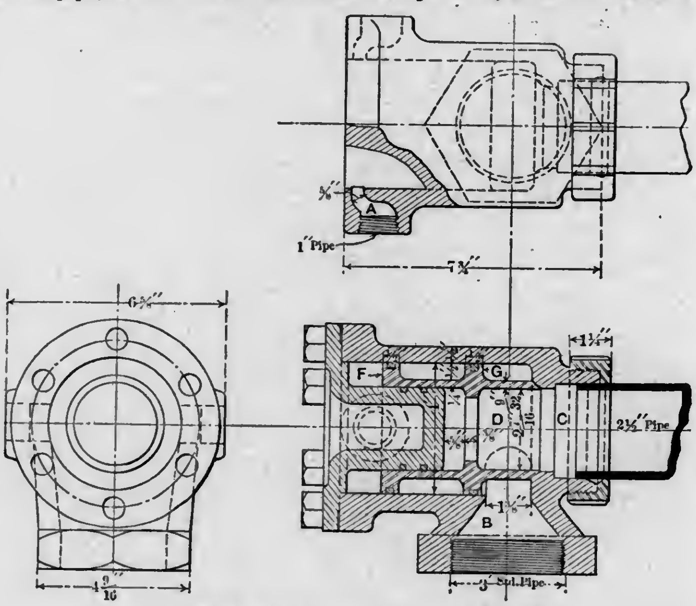
The water column is also provided with a high and low water alarm, so constructed that it can be removed and replaced in a few moments without disconnecting the top part of the column. This alarm consists of a whistle and a small valve, which is operated by an arm arranged to come in contact with either the upper or lower collar on the float rod and thus open the valve and permit steam to blow the whistle at the water level for which the collars are adjusted.

The parts of this apparatus forming valve seats and valves, as well as the small cylinder and piston of the operating valve and the piping throughout are made of brass, the other sections being of cast iron. Provision is made for attaching a water glass and gauge cock to the water column.

CYLINDER RELIEF AND VACUUM VALVE.

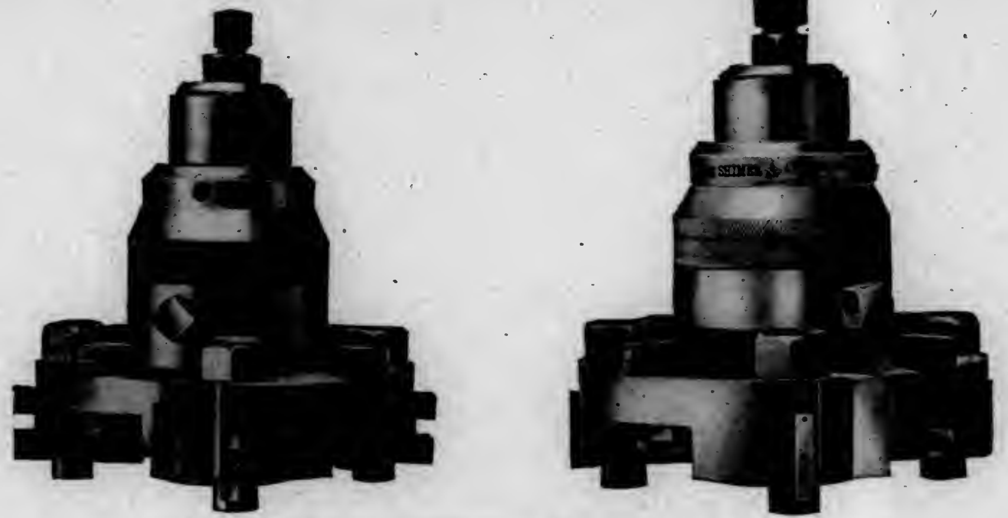
A new type of cylinder relief and vacuum valve has been desinged by Messrs. B. O. Yearwood and R. C. Patterson, of Portsmouth, Va. This valve is comparatively simple in construction and has proved itself to be very reliable in practical service. Its operation is obtained from the presence or absence of pressure in the steam chest and it does not contain any springs or adjustable parts.

The illustration shows the construction quite clearly; referring to the lettered passages and parts the operation and connection of the valve are as follows: The port A is connected by a 1 in. pipe, which should be as short as possible, to the live steam



CYLINDER RELIEF AND VACUUM VALVE.

chamber in the steam chest. This pressure then acts against face F of the valve, holding it against its seat, overcoming the resistance of the pressure against face G, which is from 15 to 20 per cent. smaller in area, and is subjected to pressure from the cylinder, connection being by a 3 in. pipe, through passage B. Passage C connects to a similar passage in a similar valve at the opposite end of the cylinder by a 2½ in. pipe. When for any reason the pressure on the cylinder rises to a point 15 or 20 per cent. above the boiler pressure the valve is then forced open and the pressure relieved through the port C to the other side of the piston. When the throttle is closed and the locomotive begins to drift the compression in the cylinder will force the valve open and the vacuum created in the steam connection will hold it in that position, allowing a free passage on both sides of the piston, from one end of the cylinder to the other.



SHIMER INTERMEDIATE CUTTER HEAD FOR HIGH SPEED MATCHERS.

INTERMEDIATE CUTTER HEAD FOR HIGH SPEED MATCHER.

A new cutter head for use on high speed matchers has recently been developed which offers several features of advantage over the ordinary types for this purpose. The head is made in two sections, and provides for perfect expansion of the tongue and grooved proportions. In this tool straight and circular bits are used in combination, the straight bits, used for cutting the vertical edge of the board, being made from flat strips of self-hardening steel. The square offsets above and below the tongue are formed by grooving out the end of the bit and projecting it to the proper distance. The finish is accomplished by the intermediate circular bits working in pairs in the upper and lower series.

Of the two sections of the head the one forming the body is a solid steel forging bored and turned to a true cylindrical form. The lower portion of the flange of this section is grooved radially at equal distances around the head in order to receive the straight pieces of cutting steel. These bits are held firmly in position by means of a mortised bolt which passes through the flange. These straight knives are intended to cut down the square edge of the grooved side and the square shoulders of the tongue side. Between the straight knives and diametrically opposite each other are arranged two small circular bits set into the flange of this section of the head so as to follow each other in the cutting of the lower portion of the tongue or groove. Between the other quarters of the straight knives the solid portion of this section is cut away and the second section, which slides over the solid central hub, has projections or lugs fitting into these openings. On these projections are two other small circular bits. These bits are capable of being adjusted by means of the expansion feature, which is controlled by an automatically locking expansion ring and assures a uniform size of tongue and groove.

As may be seen from the illustrations, this head has a perfect running balance and it is capable of turning out absolutely accurate work at an extremely rapid rate. It has been developed and is being built by Samuel J. Shimer & Sons, Milton, Pa.

VENTILATION OF STORAGE BATTERY HOUSES.

NEW YORK CENTRAL & HUDSON RIVER RAILROAD.

In connection with the electrification scheme of the New York Central terminal in New York there has been installed as part of the substation equipment, several large storage battery houses. The companies furnishing the batteries were willing to give a ten years' guarantee, provided the temperature of the battery house was maintained at 70 degs. This, of course, necessitated a heating plant for cold weather and a means of cooling in warm weather, as well as good ventilation at all times.

In considering the subject it was found that the charging of the batteries caused the discharge of destructive acid fumes, which would attack and destroy iron piping. This prevented the possible use of a direct system of radiation and made it necessary to adopt the blower system. The use of this system was also advisable because of the positive ventilation which it would afford.

The entire heating plant, for each battery house, is centralized in a detached building and the heated or cooled air is distributed to various portions of the house through ducts, which are protected in such a manner as to prevent the corrosive action of

INTERIOR OF BATTERY HOUSE AT KINGSBRIDGE SUBSTATION—NEW YORK CENTRAL.

the acid fumes. The air is circulated through a section pipe heater, which can be used for cooling as well, by means of a steel plate fan driven by a belted motor. Steam for heating is supplied by a small boiler.

Two methods of distribution have been employed, one, used at the Yonkers power station, providing several inlets to various parts of the battery room, and the other, used at the other stations, having but one large inlet at the end of the room. The latter system has been found to be as satisfactory as the former and in view of its simplicity and lower cost will probably be used in all later stations.

These heating and ventilating systems were designed by the American Blower Company of Detroit, Mich., and its apparatus is used throughout.

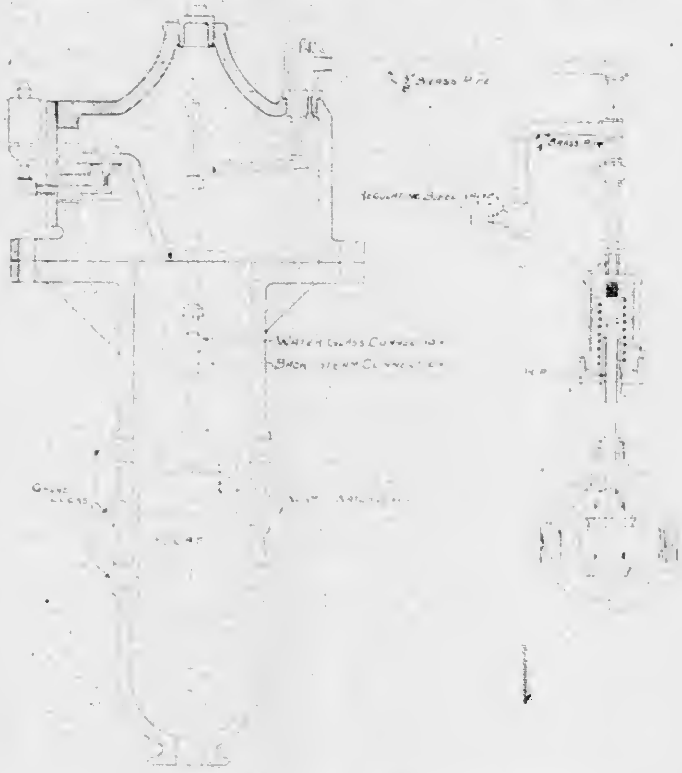
The Board of Trade reports that the Shrewsbury wreck of the London and Northwestern, October 15, 1907, when 16 persons were killed, was caused by the engineer falling asleep.

Inside clearance	0 in.
Lead, constant	3/16 in.
WHEELS.	
Driving, diameter over tires	55 in.
Driving, thickness of tires	$3\frac{1}{2}$ in.
Driving journals, diameter and length	9 × 12 in.
Engine truck wheels, diameter	33 in.
Engine truck journals	6 × 12 in.
BOILER.	
Style	Belpaire
Working pressure	210 lbs.
Outside diameter of first ring	$71\frac{1}{8}$ in.
Firebox, length and width	118 × $72\frac{1}{4}$ in.
Firebox plates, thickness	[illegible] and $\frac{5}{8}$ in.
Firebox, water space	F. [illegible] in., S. & B. $3\frac{1}{2}$ in.
Tubes, number and outside diameter	331—2 in.
Tubes, length	14 ft. 8 in.
Heating surface, tubes	2,523.5 sq. ft.
Heating surface, firebox	204.0 sq. ft.
Heating surface, total	2,727.5 sq. ft.
Grate area	59 sq. ft.
Smokestack, height above rail	15 ft. $5\frac{3}{4}$ in.
Center of boiler above rail	9 ft. 6 1/16 in.
TENDER.	
Tank	Waterbottom
Frame	12 in. channels
Wheels, diameter	36 in.
Journals, diameter and length	$5\frac{1}{2}$ × 10 in.
Water capacity	8,000 gals.
Coal capacity	13 tons

BOILER FEED WATER REGULATOR.

A new type of feed water regulator, simple in construction and reliable in action, which can be applied to any type of stationary boiler has been designed and is being manufactured by the Golden-Anderson Valve Specialty Company, Fulton Building, Pittsburg, Pa.

This device is called the Gould Safety Continuous feed water regulator and includes a specially designed water column connected by a brass pipe to a controlling valve placed in the feed line of the boiler. The water column is cast iron and contains a copper float which carries a vertical rod fitted with two collars. By adjustment of these collars the water can be carried at any



GOULD SAFETY CONTINUOUS FEED WATER REGULATOR.

desired point in the boiler and the level can be maintained with a very small variation. When the water rises the upper collar on the rod comes into contact with a lever, which opens a small valve, permitting steam pressure to pass through the brass piping to the top of the piston forming part of the controlling valve in the feed line. This piston is then partially or wholly forced downward cutting off the supply to the boiler. When the water recedes the steam valve closes and the pressure in the pipe is gradually dissipated through the regulating bleed valve and the spring beneath the piston forces it up and permits the water supply to again enter the boiler.

The valve in the water end of the feed controlling valve is of the balanced slide valve type, so constructed that any amount of back pressure in the feed line will have no effect in overcoming the steam pressure on top of the small piston. The bleed valve is capable of very close adjustment and can be so adjusted as to make the regulator hold the water level with a very slight variation.

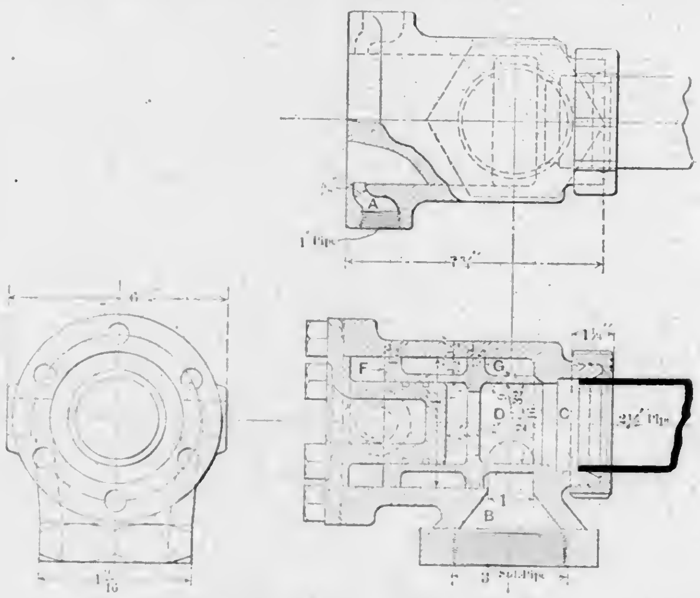
The water column is also provided with a high and low water alarm, so constructed that it can be removed and replaced in a few moments without disconnecting the top part of the column. This alarm consists of a whistle and a small valve, which is operated by an arm arranged to come in contact with either the upper or lower collar on the float rod and thus open the valve and permit steam to blow the whistle at the water level for which the collars are adjusted.

The parts of this apparatus forming valve seats and valves, as well as the small cylinder and piston of the operating valve and the piping throughout are made of brass, the other sections being of cast iron. Provision is made for attaching a water glass and gauge cock to the water column.

CYLINDER RELIEF AND VACUUM VALVE.

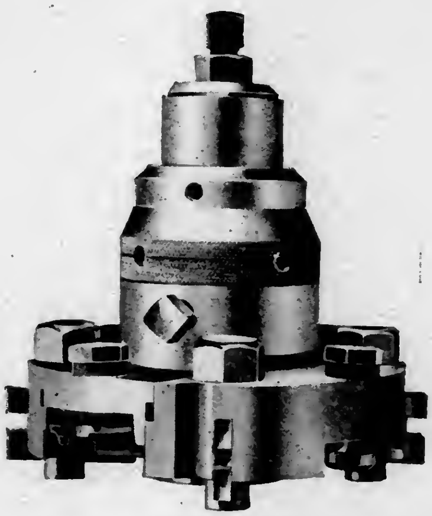
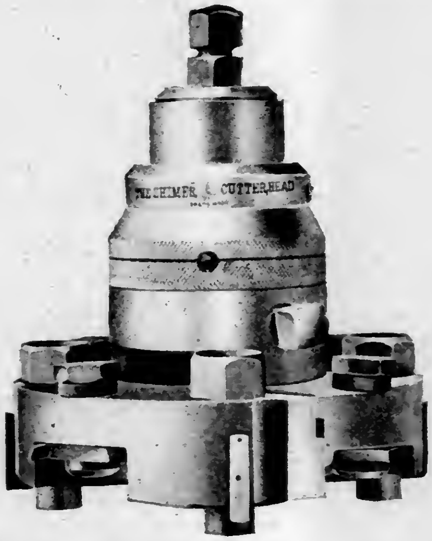
A new type of cylinder relief and vacuum valve has been desinged by Messrs. B. O. Yearwood and R. C. Patterson, of Portsmouth, Va. This valve is comparatively simple in construction and has proved itself to be very reliable in practical service. Its operation is obtained from the presence or absence of pressure in the steam chest and it does not contain any springs or adjustable parts.

The illustration shows the construction quite clearly; referring to the lettered passages and parts the operation and connection of the valve are as follows: The port A is connected by a 1 in. pipe, which should be as short as possible, to the live steam



CYLINDER RELIEF AND VACUUM VALVE.

chamber in the steam chest. This pressure then acts against face F of the valve, holding it against its seat, overcoming the resistance of the pressure against face G, which is from 15 to 20 per cent. smaller in area, and is subjected to pressure from the cylinder, connection being by a 3 in. pipe, through passage B. Passage C connects to a similar passage in a similar valve at the opposite end of the cylinder by a $2\frac{1}{2}$ in. pipe. When for any reason the pressure on the cylinder rises to a point 15 or 20 per cent. above the boiler pressure the valve is then forced open and the pressure relieved through the port C to the other side of the piston. When the throttle is closed and the locomotive begins to drift the compression in the cylinder will force the valve open and the vacuum created in the steam connection will hold it in that position, allowing a free passage on both sides of the piston, from one end of the cylinder to the other.

SHIMER INTERMEDIATE CUTTER HEAD FOR HIGH SPEED MATCHERS.

INTERMEDIATE CUTTER HEAD FOR HIGH SPEED MATCHER.

A new cutter head for use on high speed matchers has recently been developed which offers several features of advantage over the ordinary types for this purpose. The head is made in two sections, and provides for perfect expansion of the tongue and grooved proportions. In this tool straight and circular bits are used in combination, the straight bits, used for cutting the vertical edge of the board, being made from flat strips of self-hardening steel. The square offsets above and below the tongue are formed by grooving out the end of the bit and projecting it to the proper distance. The finish is accomplished by the intermediate circular bits working in pairs in the upper and lower series.

Of the two sections of the head the one forming the body is a solid steel forging bored and turned to a true cylindrical form. The lower portion of the flange of this section is grooved radially at equal distances around the head in order to receive the straight pieces of cutting steel. These bits are held firmly in position by means of a mortised bolt which passes through the flange. These straight knives are intended to cut down the square edge of the grooved side and the square shoulders of the tongue side. Between the straight knives and diametrically opposite each other are arranged two small circular bits set into the flange of this section of the head so as to follow each other in the cutting of the lower portion of the tongue or groove. Between the other quarters of the straight knives the solid portion of this section is cut away and the second section, which slides over the solid central hub, has projections or lugs fitting into these openings. On these projections are two other small circular bits. These bits are capable of being adjusted by means of the expansion feature, which is controlled by an automatically locking expansion ring and assures a uniform size of tongue and groove.

As may be seen from the illustrations, this head has a perfect running balance and it is capable of turning out absolutely accurate work at an extremely rapid rate. It has been developed and is being built by Samuel J. Shimer & Sons, Milton, Pa.

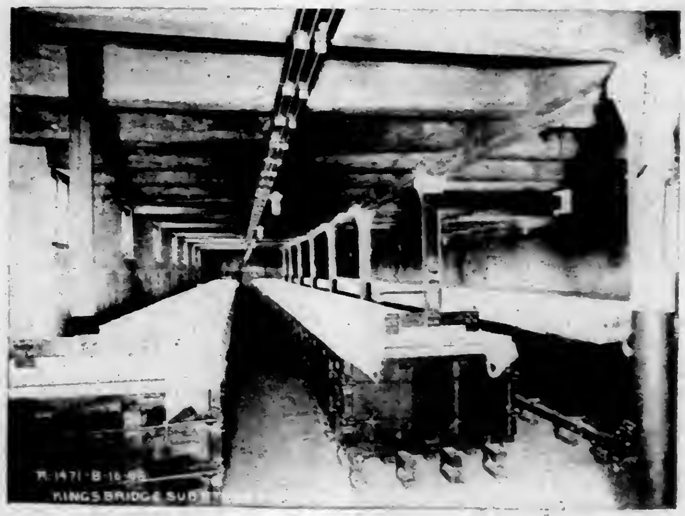
VENTILATION OF STORAGE BATTERY HOUSES.

NEW YORK CENTRAL & HUDSON RIVER RAILROAD.

In connection with the electrification scheme of the New York Central terminal in New York there has been installed as part of the substation equipment, several large storage battery houses. The companies furnishing the batteries were willing to give a ten years' guarantee, provided the temperature of the battery house was maintained at 70 degs. This, of course, necessitated a heating plant for cold weather and a means of cooling in warm weather, as well as good ventilation at all times.

In considering the subject it was found that the charging of the batteries caused the discharge of destructive acid fumes, which would attack and destroy iron piping. This prevented the possible use of a direct system of radiation and made it necessary to adopt the blower system. The use of this system was also advisable because of the positive ventilation which it would afford.

The entire heating plant, for each battery house, is centralized in a detached building and the heated or cooled air is distributed to various portions of the house through ducts, which are protected in such a manner as to prevent the corrosive action of the acid fumes. The air is circulated through a section pipe heater, which can be used for cooling as well, by means of a steel plate fan driven by a belted motor. Steam for heating is supplied by a small boiler.



INTERIOR OF BATTERY HOUSE AT KINGSBRIDGE SUBSTATION—NEW YORK CENTRAL.

Two methods of distribution have been employed, one, used at the Yonkers power station, providing several inlets to various parts of the battery room, and the other, used at the other stations, having but one large inlet at the end of the room. The latter system has been found to be as satisfactory as the former and in view of its simplicity and lower cost will probably be used in all later stations.

These heating and ventilating systems were designed by the American Blower Company of Detroit, Mich., and its apparatus is used throughout.

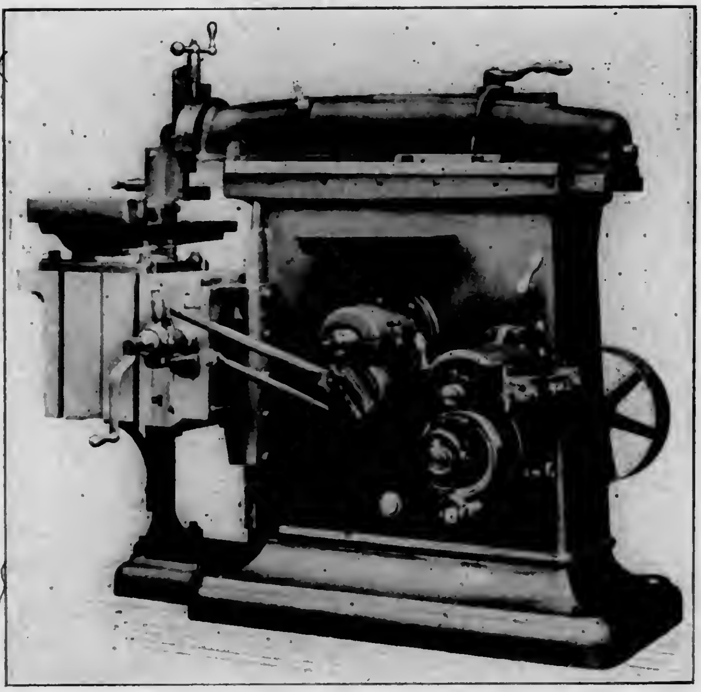
The Board of Trade reports that the Shrewsbury wreck of the London and Northwestern, October 15, 1907, when 16 persons were killed, was caused by the engineer falling asleep.

IMPROVED GEAR BOX FOR SHAPERS.

The gear box, shown in the illustration as applied to a 20 inch back geared crank shaper, is a new design of The Queen City Machine Tool Company, Cincinnati, O. It furnishes four speeds; the design is simple and the construction substantial and durable. It is easy to operate and is not at all clumsy, either in appearance or operation. Gear boxes in automobile construction have probably been developed to a more advanced stage than for any other use and it is said that the design of this new gear box is similar, in many respects, to some of the latest types used in automobile construction.

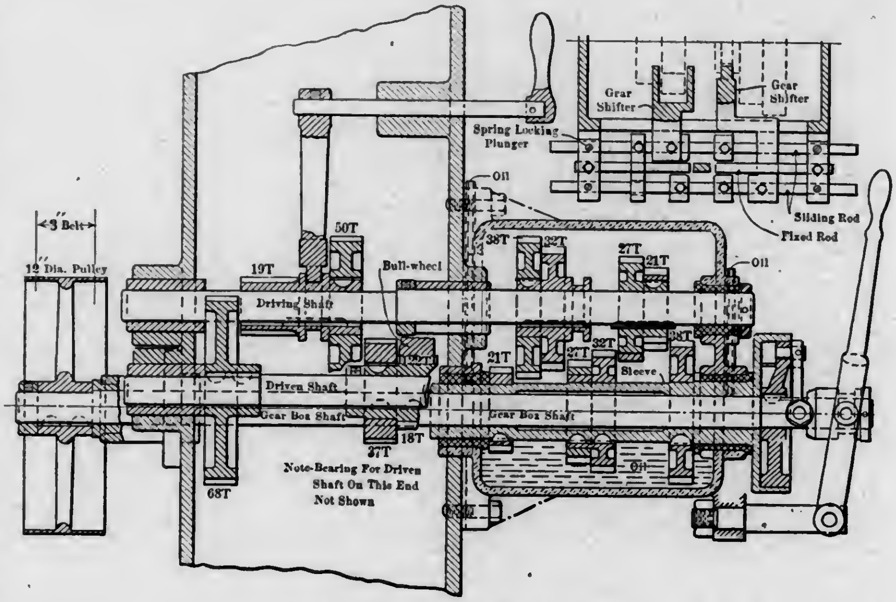
As may be seen from the drawing, the driving pulley is attached to one end of the shaft which passes through the shaper and forms the main shaft in the gear box. On this shaft is a long sleeve which has mounted on it four gears inside of the box, and the ring of the clutch on the outside. When the clutch is engaged the sleeve is driven by the shaft; when it is disengaged the sleeve revolves slowly, due to friction, unless some of the gears on it are engaged with the intermediate shaft, when it remains stationary. On the intermediate shaft are mounted four sliding gears arranged in two pairs. By means of the device shown in the upper right hand corner of the drawing, any one of these four gears may be engaged with a corresponding gear on the driving sleeve and locked in that position.

As has been stated, the sleeve rotates slowly when not engaged and no trouble is encountered in slipping the gears into mesh. It is said that the four gear box changes can be made in four seconds. This is remarkable as the expanding clutch and all of the gears are each time automatically, securely and independently locked in all the different working and idle positions. The drawing shows all of the gears disengaged and it will be seen that the length inside of the box is very little greater than the combined width of the faces of all the gears. The floor space required by the machine equipped with the gear box is not greater than when the cone belt drive is used.



QUEEN CITY SHAPER WITH GEAR BOX.

The gear box combined with the back gear arrangement, which is shown on the drawing, provides eight speeds, which give cutting strokes per minute as follows: 7.2; 10.9; 15.4; 23.5; 34.8; 53.1; 74.7; 114. The index plate aids in choosing the proper speeds. The gear box proper, in addition to being bolted to the column, has a press fit in the column. The different parts of the box are easily accessible for inspection without removing it from the column. As with the regular machines, the back gears are operated by the handle, shown above the gear box, which is pushed in or pulled out according to the speed required. The arrangements for oiling the various parts are clearly shown in the drawing.



DETAILS OF GEAR BOX FOR SHAPERS.

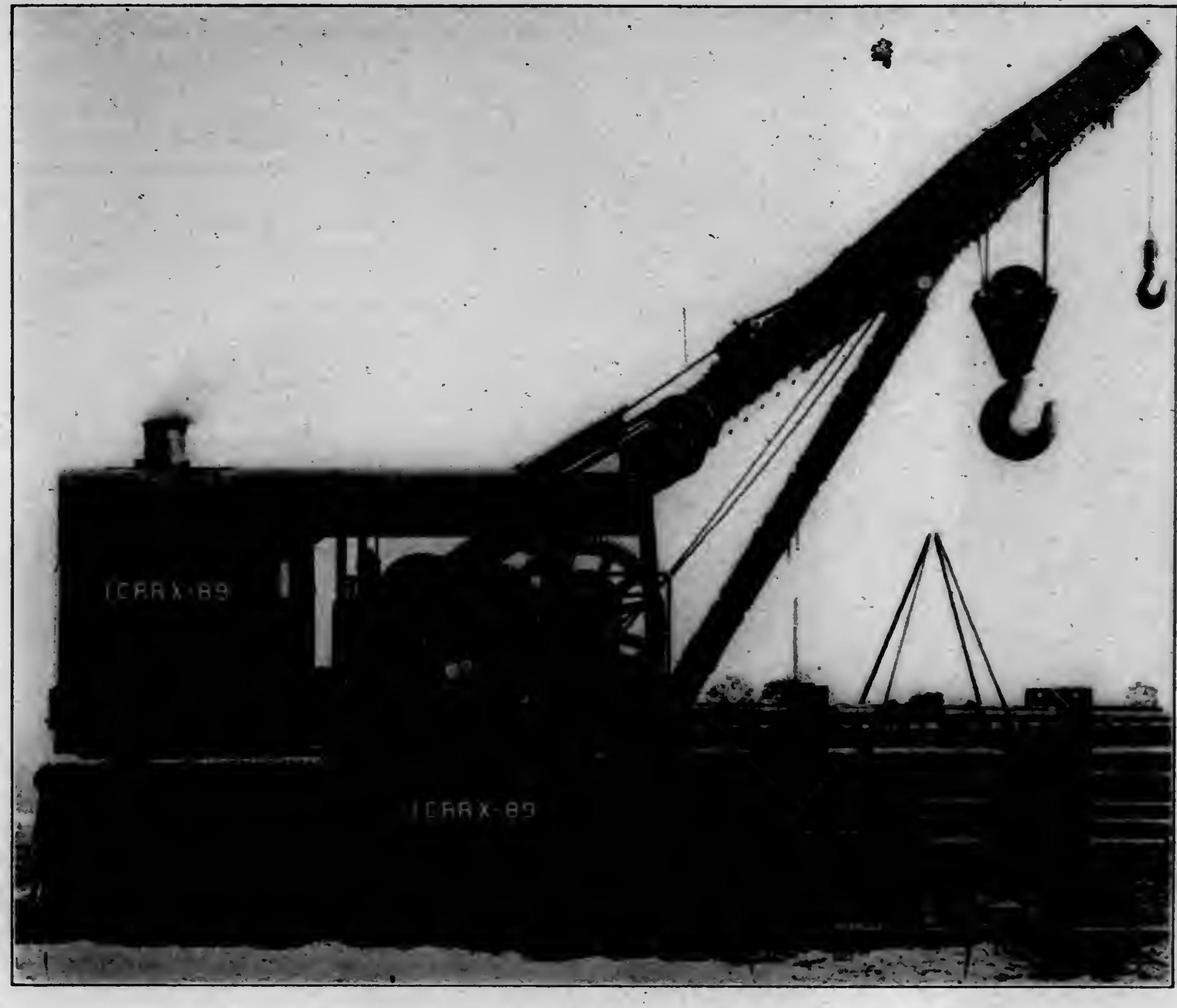
RAILROAD EARNINGS.

The reports of railroad earnings to the Interstate Commerce Commission do not admit of a comparison with the earnings of previous years, but they are now beginning to be useful as a means of studying developments in the business of transportation for a number of months past. Gross and net earnings of practically all the railroads in the country, by months, from July 1 to December 31, are now available, and the figures for January cover the earnings of 183,400 miles of road out of a total of something over 224,000 miles.

For the sake of accurate comparison the earnings have been reduced in the subjoined table to a per mile basis. The January figures are affected more or less by the fact that approximately 19 per cent. of the total mileage of the country is not included, but the portion included is so substantial that the gross and net earnings per mile are probably not far from what the complete figures will show. The net figures represent operating income after taxes have been deducted. The operating ratio represents the proportion of strictly operating expenses, exclusive of taxes, to gross earnings:

	Gross.	Net.	Op. ratio.
January	$770	$153	76.4
December	863	198	73.5
November	983	262	70.1
October	1,117	339	66.8
September	1,043	314	67.0
August	1,079	345	65.2
July	1,022	304	67.2

Gross earnings reached their maximum in October, but net earnings were not at their highest in that month, having been $6 per mile or a little less than 2 per cent. under the net returns of August. Taking the October earnings to represent the high tide of railroad prosperity the falling off in three months, as shown by the January figures, was 31 per cent. in gross earnings and 55 per cent. in net earnings after taxes. The successive operating ratios indicate how slow the railroads were to reduce expenses proportionately to the loss of business.—*Wall Street Journal.*



ICO TON WRECKING CRANE OF NEW DESIGN—ILLINOIS CENTRAL RAILROAD.

A ONE HUNDRED TON WRECKING CRANE.

ILLINOIS CENTRAL RAILROAD.

The Illinois Central Railroad has recently received a wrecking crane, built by the Shaw Electric Crane Company of Muskegon, Mich., which incorporates many new features. This crane has a capacity of 100 net tons at a 17 ft. radius, 80 tons at a 20 ft. radius and 60 tons at a 23 ft. radius, all obtained by the main hoist. In addition there is an auxiliary hoist which has a capacity of 40 tons at a 30 ft. radius, using two cables and a sheave block, and 20 tons at a 32 ft. radius with a single cable.

An important feature in the design, and one which makes possible several improvements over past practice, is the location and the position of the engines, which are reversed from the usual arrangment and have the cylinders toward the rear. This makes the piping short and direct and keeps it away from the machinery and from obstructing the engineer's passage. The main steam pipe branches at the throttle and passes downward at either side to the engine cylinders. The exhaust pipes pass underneath and are carried to a separator mounted on the back of the boiler, where the water in the exhaust steam is drawn off. The steam is then exhausted through pipes in the boiler and discharged into the stack immediately above the upper tube sheet, thus going through the whole height of the stack and giving excellent draft. This arrangement of pipes places them entirely out of the way and removes them from being subjected to strains or vibrations coming on the frame work of the crane. The keeping of the steam work to the rear in this manner makes it possible to put the side frames farther apart and keep the machinery low, resulting in a lower center of gravity and a better view from the operating platform.

The engines have an improved Walschaert valve gear, which gives a smooth action at all speeds and is easily reversed under load. The boiler has a good reserve capacity and a special arrangement of tubes permits the easy cleaning of the crown sheet. A dry pipe is provided and every precaution is taken to secure dry steam under the worst conditions. The boiler is provided with a telescopic stack, shaking and dumping grates and a dumping ash pan.

The crane is self-propelling by means of gears driving on one axle of each truck. This gearing is so arranged as not to interfere with the free movement of the trucks. A friction drive is provided in the gearing on each truck, so that any inequality in diameter of drivers is readily taken care of. Since the car is driven from both trucks it will drive equally well with the load suspended at either end. Self-lubricating center and side bearings make the crane superior to most rolling stock for taking sharp curves.

The design of the jib is a departure from past practice, as can be seen in the illustration, and avoids the combined bending and compression strains of the older type and gives a lighter and stiffer structure.

Complete air brake equipment, both automatic and straight air, are provided, and complete control of the brakes by the crane operator is provided by means of a permanent pipe connection from the crane to the car in the straight air system. Arrangements are made for the use of steam in applying the main and auxiliary hoist band brakes in addition to the usual hand applying mechanism.

The main and auxiliary hoist parts are interchangeable practically throughout. The crane is built principally of steel, very little cast iron entering into the construction. An unobstructed passage for the engineer to and from the cab has been provided on both sides of the machine.

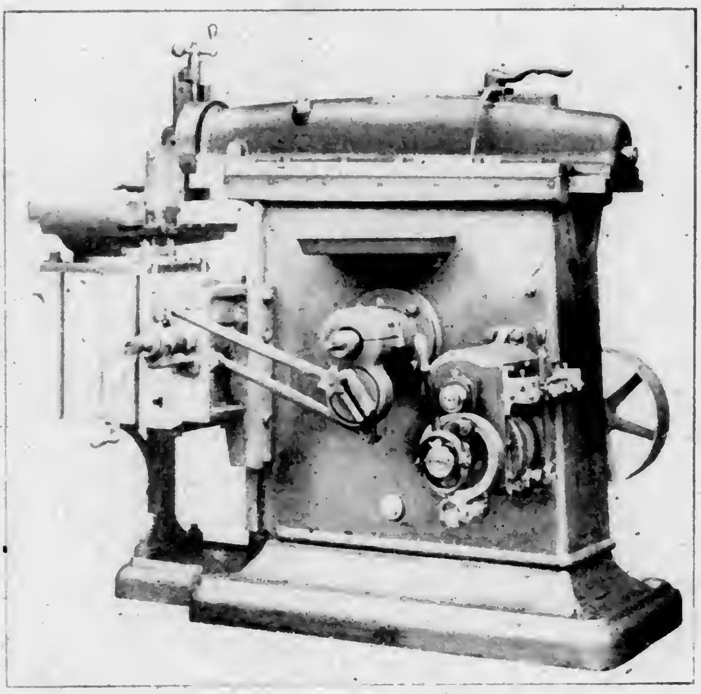
The total weight of the crane, not including coal and water, is approximately 106 tons. This machine was purchased through Manning, Maxwell & Moore, New York.

IMPROVED GEAR BOX FOR SHAPERS.

The gear box, shown in the illustration as applied to a 20 inch back geared crank shaper, is a new design of The Queen City Machine Tool Company, Cincinnati, O. It furnishes four speeds; the design is simple and the construction substantial and durable. It is easy to operate and is not at all clumsy, either in appearance or operation. Gear boxes in automobile construction have probably been developed to a more advanced stage than for any other use and it is said that the design of this new gear box is similar, in many respects, to some of the latest types used in automobile construction.

As may be seen from the drawing, the driving pulley is attached to one end of the shaft which passes through the shaper and forms the main shaft in the gear box. On this shaft is a long sleeve which has mounted on it four gears inside of the box, and the ring of the clutch on the outside. When the clutch is engaged the sleeve is driven by the shaft; when it is disengaged the sleeve revolves slowly, due to friction, unless some of the gears on it are engaged with the intermediate shaft, when it remains stationary. On the intermediate shaft are mounted four sliding gears arranged in two pairs. By means of the device shown in the upper right hand corner of the drawing, any one of these four gears may be engaged with a corresponding gear on the driving sleeve, and locked in that position.

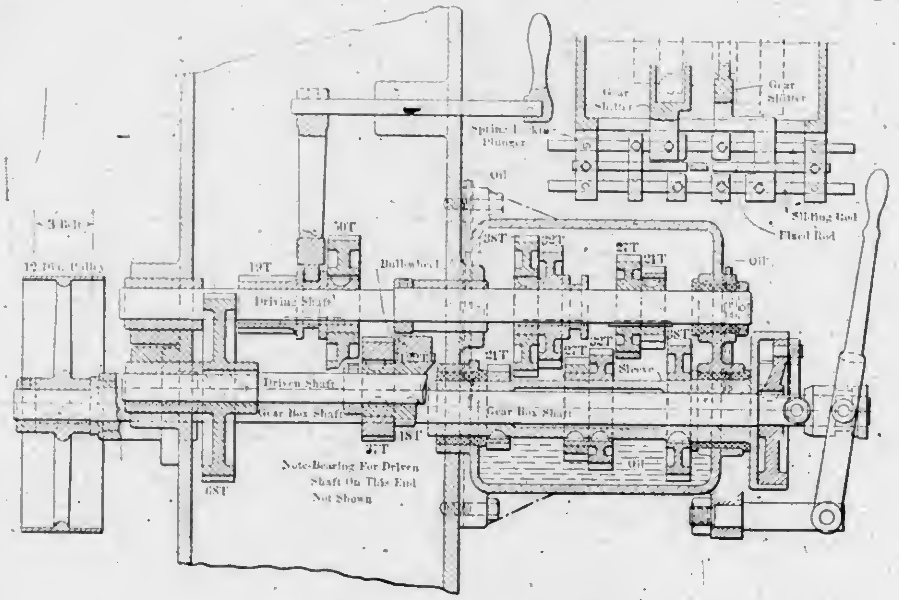
As has been stated, the sleeve rotates slowly when not engaged and no trouble is encountered in slipping the gears into mesh. It is said that the four gear box changes can be made in four seconds. This is remarkable as the expanding clutch and all of the gears are each time automatically, securely and



QUEEN CITY SHAPER WITH GEAR BOX.

independently locked in all the different working and idle positions. The drawing shows all of the gears disengaged and it will be seen that the length inside of the box is very little greater than the combined width of the faces of all the gears. The floor space required by the machine equipped with the gear box is not greater than when the cone belt drive is used.

The gear box combined with the back gear arrangement, which is shown on the drawing, provides eight speeds, which give cutting strokes per minute as follows: 7.2; 10.9; 15.4; 23.5; 34.8; 53.1; 74.7; 114. The index plate aids in choosing the proper speeds. The gear box proper, in addition to being bolted to the column, has a press fit in the column. The different parts of the box are easily accessible for inspection without removing it



DETAILS OF GEAR BOX FOR SHAPERS.

from the column. As with the regular machines, the back gears are operated by the handle, shown above the gear box, which is pushed in or pulled out according to the speed required. The arrangements for oiling the various parts are clearly shown in the drawing.

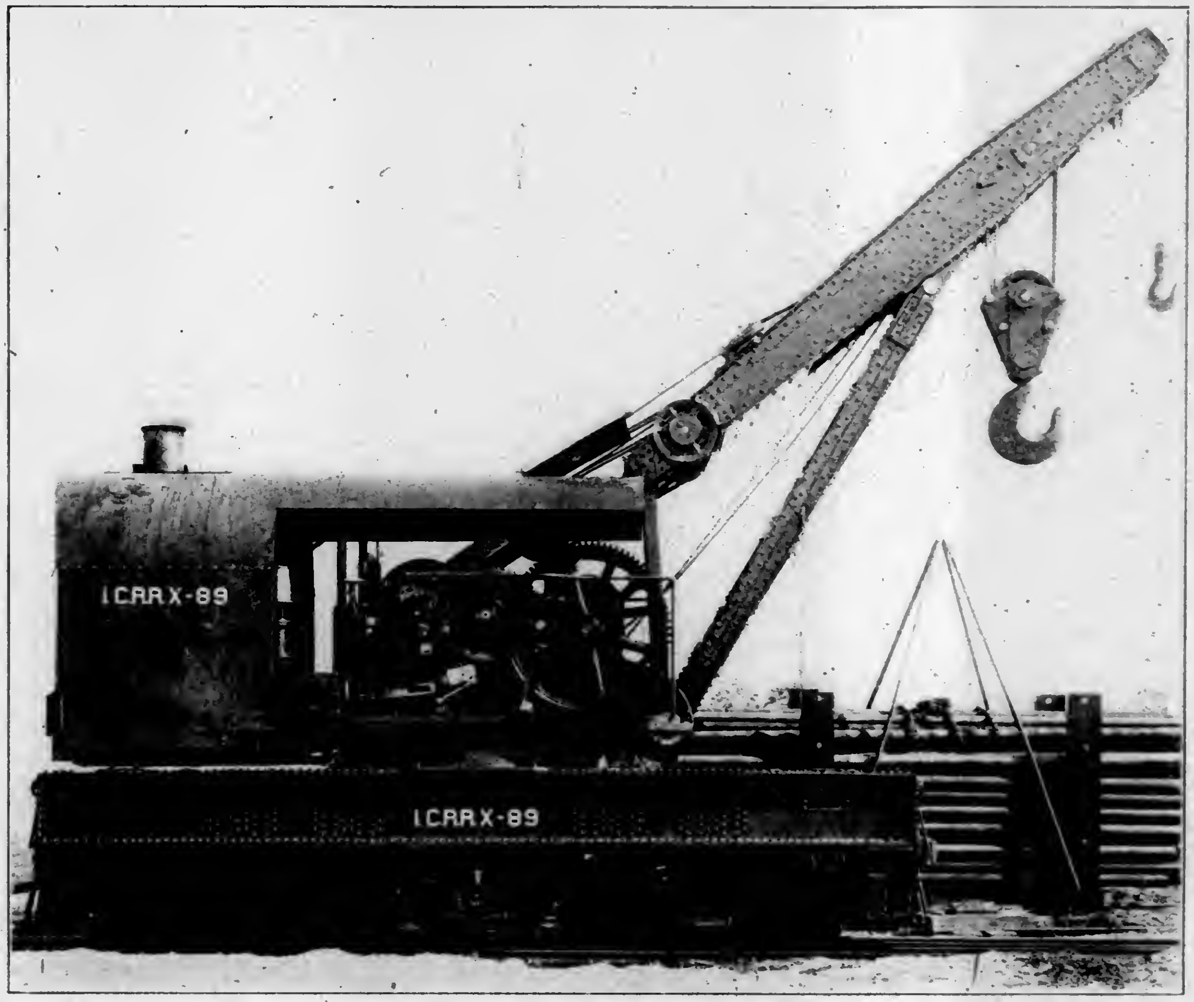
RAILROAD EARNINGS.

The reports of railroad earnings to the Interstate Commerce Commission do not admit of a comparison with the earnings of previous years, but they are now beginning to be useful as a means of studying developments in the business of transportation for a number of months past. Gross and net earnings of practically all the railroads in the country, by months, from July 1, to December 31, are now available, and the figures for January cover the earnings of 183,400 miles of road out of a total of something over 224,000 miles.

For the sake of accurate comparison the earnings have been reduced in the subjoined table to a per mile basis. The January figures are affected more or less by the fact that approximately 19 per cent. of the total mileage of the country is not included, but the portion included is so substantial that the gross and net earnings per mile are probably not far from what the complete figures will show. The net figures represent operating income after taxes have been deducted. The operating ratio represents the proportion of strictly operating expenses, exclusive of taxes, to gross earnings:

	Gross.	Net.	Op. ratio.
January	$770	$153	76.1
December	863	198	73.5
November	983	262	70.1
October	1,117	339	66.8
September	1,013	314	67.0
August	1,079	315	65.2
July	1,022	304	67.2

Gross earnings reached their maximum in October, but net earnings were not at their highest in that month, having been $6 per mile or a little less than 2 per cent. under the net returns of August. Taking the October earnings to represent the high tide of railroad prosperity the falling off in three months, as shown by the January figures, was 31 per cent. in gross earnings and 55 per cent. in net earnings after taxes. The successive operating ratios indicate how slow the railroads were to reduce expenses proportionately to the loss of business.—*Wall Street Journal.*



100 TON WRECKING CRANE OF NEW DESIGN—ILLINOIS CENTRAL RAILROAD.

A ONE HUNDRED TON WRECKING CRANE.

ILLINOIS CENTRAL RAILROAD.

The Illinois Central Railroad has recently received a wrecking crane, built by the Shaw Electric Crane Company of Muskegon, Mich., which incorporates many new features. This crane has a capacity of 100 net tons at a 17 ft. radius, 80 tons at a 20 ft. radius and 60 tons at a 23 ft. radius, all obtained by the main hoist. In addition there is an auxiliary hoist which has a capacity of 40 tons at a 30 ft. radius, using two cables and a sheave block, and 20 tons at a 32 ft. radius with a single cable.

An important feature in the design, and one which makes possible several improvements over past practice, is the location and the position of the engines, which are reversed from the usual arrangment and have the cylinders toward the rear. This makes the piping short and direct and keeps it away from the machinery and from obstructing the engineer's passage. The main steam pipe branches at the throttle and passes downward at either side to the engine cylinders. The exhaust pipes pass underneath and are carried to a separator mounted on the back of the boiler, where the water in the exhaust steam is drawn-off. The steam is then exhausted through pipes in the boiler and discharged into the stack immediately above the upper tube sheet, thus going through the whole height of the stack and giving excellent draft. This arrangement of pipes places them entirely out of the way and removes them from being subjected to strains or vibrations coming on the frame work of the crane. The keeping of the steam work to the rear in this manner makes it possible to put the side frames farther apart and keep the machinery low, resulting in a lower center of gravity and a better view from the operating platform.

The engines have an improved Walschaert valve gear, which gives a smooth action at all speeds and is easily reversed under load. The boiler has a good reserve capacity and a special arrangement of tubes permits the easy cleaning of the crown sheet. A dry pipe is provided and every precaution is taken to secure dry steam under the worst conditions. The boiler is provided with a telescopic stack, shaking and dumping grates and a dumping ash pan.

The crane is self-propelling by means of gears driving on one axle of each truck. This gearing is so arranged as not to interfere with the free movement of the trucks. A friction drive is provided in the gearing on each truck, so that any inequality in diameter of drivers is readily taken care of. Since the car is driven from both trucks it will drive equally well with the load suspended at either end. Self-lubricating center and side bearings make the crane superior to most rolling stock for taking sharp curves.

The design of the jib is a departure from past practice, as can be seen in the illustration, and avoids the combined bending and compression strains of the older type and gives a lighter and stiffer structure.

Complete air brake equipment, both automatic and straight air, are provided, and complete control of the brakes by the crane operator is provided by means of a permanent pipe connection from the crane to the car in the straight air system. Arrangements are made for the use of steam in applying the main and auxiliary hoist band brakes in addition to the usual hand applying mechanism.

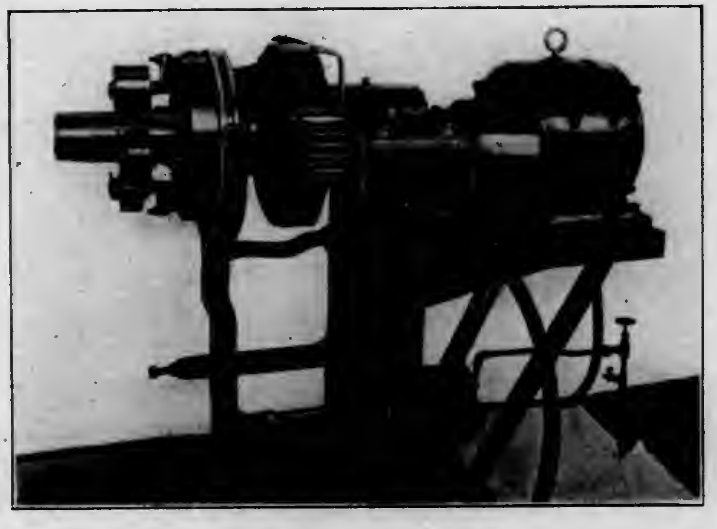
The main and auxiliary hoist parts are interchangeable practically throughout. The crane is built principally of steel, very little cast iron entering into the construction. An unobstructed passage for the engineer to and from the cab has been provided on both sides of the machine.

The total weight of the crane, not including coal and water, is approximately 106 tons. This machine was purchased through Manning, Maxwell & Moore, New York.

MOTOR DRIVEN TUBE WELDING MACHINE.

The illustration shows a tube welding machine which is standard on the Canadian Pacific Railroad, and was designed and patented by Walter Byrd, general foreman at Revelstoke, B. C. In using this tool the scarfing machine has been dispensed with. The safe end is expanded by an air machine, so that it will slip over the tube 3/16 in. The tube is pushed over the stationary mandrel on the machine and the safe end is welded on by forcing down the revolving rollers by means of a compressed air device, which is operated by the foot. The machine may be adjusted for any size tube, or gauge, and the rollers may be removed and replaced by disc cutters for cutting tubes.

The machine may be adapted for either belt or motor drive.



BYRD TUBE WELDING MACHINE.

The motor shown in the illustration is of 5 h.p. capacity, operating at 1,800 r. p. m., the rollers making 750 r. p. m. The shafts upon which the rollers are mounted pass through holes in the large ring and are pivoted to the large gear as shown. The shafts pass through the ring at a slight angle and the ring may be moved in or out, parallel to the axes of the mandrel. Both the gear and the ring revolve on water cooled centers.

By pressing a treadle with the foot air is admitted to the small cylinder at the base of the machine and the upper part of the large lever, the fork of which engages with the slot in the large ring, moves to the right, thus forcing the rollers toward the mandrel. When the tube has been rolled to gauge the foot is removed from the treadle and a spring in the cylinder brings the lever back to its former position, releasing the pressure on the rollers. The mandrel may be easily removed when necessary.

PERSONALS.

John T. Luscombe has been appointed master mechanic of the Toledo & Ohio Central Ry. at Bucyrus, Ohio.

W. J. Spearman has been appointed to the new office of master mechanic of the Idaho & Washington Northern Ry., with office at Coeur D'Alene, Idaho.

The office of R. Tawse, superintendent of motive power of the Detroit, Toledo & Ironton Ry. and the Ann Arbor R. R., has been moved from Jackson, Ohio, to Toledo.

Hugo Schaefer has been appointed master mechanic of the Panhandle division of the Atchison, Topeka & Santa Fe Ry., to succeed O. A. Fisher. Mr. Schaefer's headquarters will be at Wellington, Kan.

H. W. Watts, master car builder of the Monongahela Connecting Railroad, died on April 13 at Pittsburg, Pa., at the age of 57 years. Mr. Watts was also president of the Railway Club of Pittsburg.

W. J. Monroe has been appointed master mechanic of the Oklahoma and Panhandle divisions of the Chicago, Rock Island & Pacific Ry., with headquarters at Chickasha, Okla., vice E. E. Chrysler, resigned.

J. W. Storey has been appointed mechanical engineer of the Central of Georgia Ry., with headquarters at Savannah, Ga. Mr. Storey formerly held the same position with the Cincinnati, New Orleans & Texas Pacific Ry. at Ludlow, Ky.

F. R. Cooper, superintendent of motive power of the South Buffalo Ry., has been appointed superintendent of machinery of the Kansas City Southern Ry., with headquarters at Pittsburgh, Kan., to succeed R. M. Galbraith, resigned.

J. H. Sanford has been appointed purchasing agent of the New York, New Haven & Hartford R. R. He succeeds to the duties of A. E. Mitchell, manager of purchases and supplies, resigned. The latter title has been abolished.

G. F. Weiseckel, general foreman of the Baltimore & Ohio Ry. at Glenwood, Pa., has been appointed master mechanic of the Cumberland division to succeed A. H. Hodges, resigned. Mr. Weiseckel's headquarters will be at Cumberland, Md.

D. R. MacBain, assistant superintendent of motive power of the Michigan Central R. R. at Detroit, Mich., has been appointed assistant superintendent of motive power of the New York Central & Hudson River R. R., with headquarters at Albany, N. Y.

THE COAL INDUSTRY IN 1907.—A production of between 450,000,000 and 460,000,000 net tons of coal in the United States in 1907 is indicated by the returns received thus far by the United States Geological Survey, or an increase of about 10 per cent. over the record breaking output of 1906, according to E. W. Parker, coal expert and chief statistician of the survey. The most notable increase was made in the production of Pennsylvania anthracite, in which a gain of over 20 per cent. was recorded. The shipments of anthracite in 1907 amounted to 67,109,393 gross tons, as against 55,696,595 gross tons in 1906. This would indicate a total production for the year of approximately 76,366,000 gross tons, or about 85,840,000 net tons.

BOOK NOTES.

Locomotive Break Downs. By Geo. L. Fowler. Revised and enlarged by W. W. Wood. 266 pages. 4½ x 6¾. Flexible covers. Illustrated. Published by the Norman W. Henley Publishing Co., 132 Nassau St., New York. Price, $1.00.

This book, which is arranged in catechism form, covers very fully all possible accidents to locomotives and their appliances. The earlier editions, which are well known to most enginemen, have been completely revised and in addition to features concerning the Walschaert valve gear and electric head lights, much new matter in connection with air brakes, has been added. It is carefully illustrated with line drawings, which clearly explain the methods suggested for making repairs. The index has been made very complete and in cases of emergency will permit the rapid examination of the procedure recommended. A book of this kind is practically indispensable to young runners.

Method for Earthwork Computations. By C. W. Crockett, Professor of Mathematics and Astronomy, Rensselaer Polytechnic Institute. Cloth; 114 pages; 5¾ x 9. Illustrated. Published by John Wiley & Sons, 43 E. 19th St., New York. Price $1.50.

An attempt has been made in this book to formulate a series of rules by which the terms necessary for the numerical computation of earthwork volumes, either by the prismoidal formula or by the average end area method, may be written directly from the notes. The author has prepared a slide rule, which is described in chapter six of the book, that may be used for all earth work determination. The arrangement of the scales on this

rule are such as to make the instrument very general in application. The work is most completely illustrated and excellently arranged.

Locomotive Catechism. By Robert Grimshaw. 27th Edition. Revised and enlarged. 817 pages. 4¾ x 7¼. Cloth. Illustrated. Published by the Norman W. Henley Publishing Co., 132 Nassau St., New York. Price, $2.50.

This edition of the well known catechism has been so thoroughly revised that it may be said to be practically a new work. It has been greatly enlarged and the matter has been more conveniently arranged. It contains nearly 4,000 questions and answers in connection with the design, construction, repair and running of all kinds of locomotives, which are accompanied by 437 illustrations. The work is intended as a preparation for examination and the instruction of engineers, firemen, trainmen, switchmen, shop and roundhouse men. All of the very latest features in locomotive construction have been considered.

Manual of Recommended Practice for Railway Engineering and Maintenance of Way. Cloth. 6 x 9. 290 pages. Illustrated. Published by the American Railway Engineering & Maintenance of Way Association, 962 Monadnock Block, Chicago. Price, $3.00.

This book contains the definitions, specifications and principles of practice adopted and recommended by the American Railway Engineering & Maintenance of Way Association and consists of a compilation of recommendations on the various subjects which have been most carefully discussed and finally voted upon by the association. The work has been handled by sixteen different committees, dealing with the following subjects: roadway, ballasting; ties; rail; track; buildings; wooden bridges and trestles; masonry; signs, fences, crossings and cattle-guards; signaling and interlocking; records, reports and accounts; uniform rules; organization, titles, codes, etc.; water service; yards; terminals; iron and steel structures and classification of track. The last edition has been revised down to the end of 1907.

Engineering Index Annual for 1907. Cloth; 434 pages; 6½ x 9½. Published by the Engineering Magazine, 140 Nassau St., New York. Price $2.00.

The compiling of an index of all technical and scientific articles of importance, which have appeared during the year in technical papers of all countries, and incorporating it in one volume, is a scheme which is most thoroughly appreciated by all engineers and others who have occasion to look up information on technical subjects. This yearly volume is taken from the index published monthly in the Engineering Magazine and in order to make it commercially practical and of a reasonable price, the same scheme of classification is followed as is used in the monthly parts. It has been found that this annual form of index has a large advantage over five-year volumes, both to the consultant and the publishers, since it indexes current literature which is timely and fresh and easily procurable if desired. In the 1907 volume the details of the classification have been slightly modified and improved, special efforts being made to standardize catch words, and cross referencing has been introduced on a larger scale than in the preceding number.

Power and Power Transmission. By E. W. Kerr, Professor of Mechanical Engineering, Louisiana State University. Second edition. Revised. Cloth; 366 pages; 5¾ x 9. Published by John Wiley & Sons, 43 East 19th St., New York. Price $2.00.

The first edition of this work, which appeared in 1902, has been improved by the re-writing of the chapters on steam turbines and valve diagrams, and by the addition of several pages of matter upon the subject of heat and the use of the steam table. A new steam table has replaced the one in the earlier edition. A large number of problems have also been added, and the whole work thoroughly revised. It forms a treatise on power and power transmission, dealing with the elementary principles of these subjects. It is not intended as an exhaustive treatment in any respect, but will be found to be of great value in giving the guiding principles for a more thorough investigation. Examples are given at the end of each chapter for the purpose of fixing in the mind of the student the more important principles contained therein. Many of these examples are from practice. It is divided into three general parts. The first dealing with machinery and mechanics; the second with steam engines, valve gears and turbines, and the third with pumps, gas engines, water power and compressed air. The whole work is very comprehensive and is thoroughly illustrated.

Profit Making in Shop and Factory Management. By Charles U. Carpenter. Published by The Engineering Magazine, 140 Nassau St., New York. 1908. 6 x 9 in. Cloth. 146 pages. Price $2.00.

While this treatise was prepared with the needs of a manufacturing plant in view there is much in it which may be applied to railroad repair shops with excellent results. The book is in main a reprint of articles which appeared in The Engineering Magazine last year. These have been revised and enlarged and re-arranged for more immediate effectiveness. A superintendent of motive power of a railroad, whose shops are considered among the best managed in the country, spoke of these articles, when they first appeared, as being of great value in helping him to improve the shop organization and increase the production.

The contents of the book by chapters is as as follows: Reorganization of a run-down concern; practical working of the committee system; reports, their necessity and their uses; designing and drafting department; the tool room, the heart of the shop; minimizing the time of machine-tool operations; possibilities attending the use of high-speed steel; determination of standard times for machining operation; standard times for handling the work; standard times for assembling; stimulating production by the wage system; stock and cost systems as a factor in profit making; upbuilding of a selling organization; effective organization in the executive department.

Mr. Carpenter is president of the Herring-Hall-Marvin Safe Company and the methods described in the book are those which he found most successful in the re-organization of that company, and as superintendent of production in other large manufacturing plants, including the National Cash Register Company.

The Elements of Railroad Engineering. By Wm. G. Raymond, C.E., LL.D. 405 pages. 6 x 9. Bound in cloth. Illustrated. Published by John Wiley & Sons, New York. Price, $3.50.

This work describes the physical properties of a railroad and gives the underlying principles of their design. The policy adopted in the preparation of the work has been to treat briefly and generally those subjects which are fully covered in special volumes, to which reference is made, and to go into details in those subjects treated only in books of this kind. The plan of the book is of first describing the thing and then discussing its design. It is divided into three parts. The first, which follows a very comprehensive introduction, is on the subject of permanent way, dealing with the theory and design of all parts of this subject. The second part is on the locomotive and its work. This does not go into the design of the locomotive except in so far as it affects the design of the track. It gives the procedure for determining the features of a locomotive in connection with speed and grade problems, ~~as well as~~ the effect of grades and curves, number of trains, tonnage, etc. This section of the book will be found to be as interesting and valuable to the mechanical engineer as to the civil. Part III. is on the subject of railroad location, construction and preliminary surveys. An appendix of 62 pages, consisting of the reprint of a paper by Mr. W. D. Taylor, with part of the discussion thereon, which gives in detail the location of the Knoxville, LaFollette & Jellico Railroad of the Louisville & Nashville System, is included. This paper is given as an example from practice of the more important principles discussed in the book. While this book has been designed primarily as a text-book, it will be found to be most convenient for reference. It forms Volume II. of a series by this author, the others now being in the course of preparation.

Automatic Block Signals and Signal Circuits. By Ralph Scott. 6 x 8. Cloth. 243 pages. Illustrated. Published by the McGraw Publishing Co., New York. Price, $2.50.

American practice in the installation and maintenance of signals electrically controlled and operated by electric or other power, together with descriptions of the accessories now regarded as standard, is set forth in a very clear and interesting manner in this book. While it is primarily intended for the signal and railway engineers, it is written in such form as to be of interest to the layman or railway man who is not versed in the work of this department. It is profusely illustrated with diagrams and half-tone illustrations, which serve to make the text matter easily comprehended by such readers.

The Strength of Chain Links. By G. A. Goodenough and L. E. Moore. Bulletin No. 18, Engineering Experiment Station, University of Illinois. Paper; 6 x 9; 73 pages. Illustrated. May be obtained by request from the Director of the Engineering Experiment Station, Urbana, Ill.

This bulletin gives the results of a series of experiments on chain links and circular rings, which covered a period of two years, and were made for the purpose of confirming or disproving the theoretical analysis of the stresses in links and rings. The results are a complete confirmation of the analysis. The bending moments and maximum stresses for links of various forms are calculated and the results of the calculations are given in the bulletin. It contains four appendixes, giving in full the theoretical discussion which was the basis of the experimental work. This bulletin will be found to be of special interest to all engineers and manufacturers who are concerned in any way with hoisting and power transmission.

CATALOGS

IN WRITING FOR THESE PLEASE MENTION THIS JOURNAL.

General Electric Company.—Among the recent bulletins issued by this company are No. 4570, which illustrates and describes the new Tungsten lamps for 100 and 125 volt circuits, and No. 4573, quite an elaborate publication on the subject of lightning arresters, of which many different types are illustrated and described.

B. F. Sturtevant Co.—Bulletin No. 153 of the Sturtevant Engineering Series has recently been issued. It contains a reprint of an article from the *Engineering Magazine* of January, 1908, bearing the caption "There is Nothing New—Not Even in Fans." This article briefly traces the development of the fan blower from the time Mr. Sturtevant introduced his first fan fifty years ago.

Staybolts, Their Use and Abuse—The Falls Hollow Staybolt Company, Cuyahoga Falls, O., is issuing a small book containing an article on the above subject by Mr. John Hickey, which is based on a long experience in active railroad work, and draws attention to many features, which are generally overlooked by master mechanics and others, in the matter of proper design and maintenance of staybolts.

Flexible Shaft.—The Coates Clipper Mfg. Co., Worcester, Mass., is issuing a catalog describing its hardened steel, ball and socket joint, flexible shaft, which is claimed to have many advantages over the wire cable flexible shaft. It gives a solid steady drive throughout its entire length and is capable of transmitting as much power backwards as forwards. The illustrations in the catalogue show the great variety of places where a shaft of this type can be used to advantage.

Sterling Lubricators.—The Sterling Lubricator Company, Rochester, N. Y., is issuing a small catalog, which fully describes and illustrates several designs and arrangements of force feed lubricators. These lubricators can be furnished with any number of feed pipes and in practically any capacity of reservoir. They are all automatic and capable of very delicate adjustment, each feed being separately adjustable. The construction is such as to give a much smaller drop than usual, which permits a much more regular and positive lubrication with a smaller amount of oil.

Champion Power Hammer.—Beaudry & Co., 141 Milk St., Boston, Mass., is issuing a small leaflet describing the Beaudry Champion hammer, which is built in sizes from 50 to 500 lbs. weight of ram, and is adapted for all kinds of forgings. The foremost claims made for this hammer are superior elasticity and perfect control of the force of the blow struck by it. These are obtained by a new device which is very simple and direct acting. The leaflet fully describes the construction of the hammer and contains a table of dimensions, weights and prices.

Jeffrey Mine Equipment.—The Jeffrey Mfg. Co., Columbus, O., is issuing a leaflet, largely given up to illustrations, which shows fourteen Jeffrey specialties of special interest to mining engineers.

Welding Pipes and Rods.—The Goldschmidt Thermit Company, 90 West street, New York, is issuing a leaflet illustrating and describing the apparatus and process for satisfactorily butt-welding tubes and rods by the use of thermit. The equipment shown is arranged for welding either horizontal or vertical pipes and is suitable for use in very close quarters.

Corrugated Fire Boxes and Flexible Tube Plates.—William H. Wood, Engineer, Media, Pa., is issuing a catalog descriptive of his design of locomotive fire boxes and tube plates, which provide perfect flexibility and allow expansion in all directions without putting unnecessary strains at the joints and ends of the tubes. The corrugated type of fire box gives an increased amount of heating surface, fewer staybolts and a large reduction in trouble with leaky joints and mud rings. The illustrations give working drawings of these fire boxes, which are now being applied on several railroads.

Engine Lathes.—The 1908 edition of The Lodge & Shipley Machine Tool Company, Cincinnati, Ohio, catalog, is considerably larger and more complete than its predecessors. Their well known patented headstock is clearly described with the aid of well-chosen illustrations, as is also the cone headstock. The tailstock and bed, carriage and apron, and screw cutting and feeds are described in detail with both half-tones and line drawings. Specifications are given for the various sizes of both the patent head and cone headstock engine lathes. Several pages are devoted to a consideration of individual motor drives; also to turrets and accessories which the company is prepared to furnish with its lathes.

NOTES

S. Obermayer Company.—Mr. J. E. Evans, for the past twenty years Chicago representative of the above company, was elected alderman of his ward at the last election held in that city.

American Locomotive Company.—The general offices of the above company were removed on April 24, 1908, from 111 Broadway to the Cortlandt Building, 30 Church street, New York.

American Steam Gauge & Valve Mfg. Co.—Mr. E. H. Webster, who has had several years' experience in mechanical lines, has accepted a position with the above company and will make his headquarters at its Chicago office.

Westinghouse Electric and Manufacturing Co.—The executive, sales and export offices of the above company formerly located at 111 Broadway and 11 Pine street, New York, were removed to the new City Investing Building, 165 Broadway, on April 20, 1908.

Falls Hollow Staybolt Company.—The staybolts to be used in the thirty locomotives for the Paris-Orleans Railway of France, now being built by the American Locomotive Company, will be made from hollow staybolt iron furnished by the above company.

Westinghouse Machine Company.—Mr. E. E. Keller, for over twenty years connected with the Westinghouse interests, and for fourteen years vice-president of the Westinghouse Machine Company, having completed his duties as receiver and general manager, has severed his connection with the management of that company and will take a much needed rest.

Machine Sales Co.—Mr. P R. Brooks has been appointed general manager of the above company, with a business address at 68 William street, New York. This company has a large and exceptionally well equipped manufacturing plant at Peabody, Mass., where it is prepared to build presses, machine tools, gas engines and special machinery of all kinds from specifications.

Quincy-Manchester-Sargent Company.—This company has decided to discontinue the manufacture of the line of pneumatic compression riveters which it acquired at the time of the purchase of the Pedrick & Ayer Co., and has disposed of this part of its product to the Hanna Engineering Company of Chicago, who will improve the machines and be in a position to furnish repair parts for all riveters that have been sold in the past. The discontinuing of the manufacturing of this line will permit the company to devote more attention to its metal sawing machines, cranes and hoists and car steps.

Locomotives—New York Central Lines.—The order of 136 locomotives received by the American Locomotive Company from the New York Central Lines, is to be composed of the following different types. For service on the New York Central & Hudson River Railroad, 20 Pacific type, 22 x 28 in. cylinders; 45 consolidation type, 23 x 32 in. cylinders, and 29 six-wheel switching type, 21 x 28 in. cylinders. For the Boston & Albany Division, 12 Pacific type; 20 consolidation type, and 10 six-wheel switching, having the same size cylinders as above. In addition to these steam locomotives this company has also received an order for twelve electric locomotives from the New York Central.

A PRACTICAL DRAWING OFFICE SYSTEM

CANADIAN PACIFIC RAILWAY.

BY G. I. EVANS, CHIEF DRAUGHTSMAN.

SYNOPSIS.

The efficiency of the drawing office system of a manufacturing plant building modern machinery is reflected, to a large extent, by increased production and decreased cost, which is made possible by economical design and careful attention to standardization. Under present conditions of railroading in America, it is evident that railroads which are building part of their equipment, or even keeping it in repair at shops of their own, are on a plane with a manufacturing plant, and that standardization, which can best be handled by the drawing office, is the most important issue in the motive power department.

To be in a position to handle this work intelligently, a very necessary part of the drawing office equipment is a complete set of records of all rolling stock and other equipment, which, by means of some practical system of indexing and filing, must be readily accessible. These records must be kept up to date with the improvements and additions which are constantly being made. Besides this, it is necessary that a large amount of information, in convenient form, be placed at the disposal of motive power officials at distant points, which will keep them thoroughly posted as to repair parts, standards which have been adopted, regulations governing the performance of certain duties, such as testing boilers, etc., and a number of other subjects. The system at present in use in the motive power drawing office of the Canadian Pacific Railway has been evolved to fill these requirements, and is as follows:

Drawing Tables.—The office equipment is arranged, as far as possible, with a view of dividing the work under different leading, or elevation draughtsmen, who lay out, direct and check the work of the detail men; the disposal of the drawing tables is then, naturally, in the direction of keeping the detail men near the leading draughtsman. This can conveniently be arranged by means of double tables at which the men face each other, and for this reason the three-man table, shown in Fig. 1, has been adopted, the leading man occupying one side which has a surface of 100 x 38 in., the other side, which is 100 x 30 in., being divided between the two detail men. Three instrument drawers are provided, and one large drawer on the leading man's side for holding reference work; the tables are also fitted with slides, arranged to pull out from underneath the tops, and a large shelf underneath the body of the table which is used for holding reference drawings during working hours. Besides these a small reference table is also used, as shown in Fig. 2.

No drawing boards are used, the tops of the tables being inclined about 1 in 6, the height at the front being 36½ in., which represents average conditions. T squares are also dispensed with, a straight edge 30 in. long and two large triangles being used for laying down base lines; this system is somewhat faster and is much less cumbersome than where a very long and heavy T square is used.

Drawing Paper for Elevations.—Elevation drawings of locomotives, cars and other large equipment are made to a scale of 1½ in. to the foot, on cloth-backed elevation sheets which are manufactured to specifications and are rigidly inspected before acceptance. These sheets are purchased in two sizes, 26 x 75 in., which is used for the largest elevations, such as 4-6-2 type locomotives, and 26 x 66 in., which is used for ordinary elevations. One of

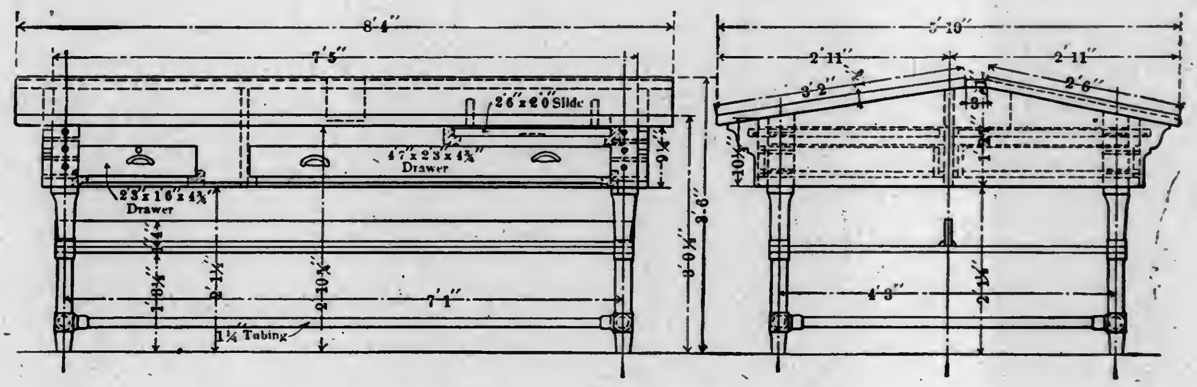


FIG. 1.—DRAWING TABLE FOR A LEADING DRAFTSMAN AND TWO DETAIL MEN.

the requirements is that the sheets be supplied in a flat condition, which is very important, as they are not tacked down to the tables, but are simply laid on them. The drawing, when completed, will show practically all parts of the locomotive, or other appliance, and is filed as part of the office record after a tracing, which shows all parts necessary for issue to the shops, has been made from it.

Filing System.—The fundamental principle of the system adopted is that of dividing all equipment, of which records are kept, into distinct classes, each of which is designated by a classification letter as follows:

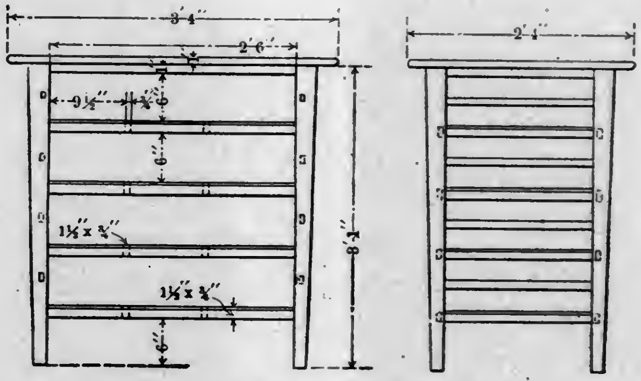


FIG. 2.—SMALL TABLE FOR REFERENCE DRAWINGS, ETC.

GROUP.	NO.	GROUP.	NO.	GROUP.	NO.
Ash Pan.	11	Front and Rear End.	44	Tool Box and Cab Seat.	75
Axle, E. & T., Crank Pin.	12	Gauge, Die, Jig, Flange Block,		Wheel, Engine and Tender.	76
Boiler.	13	etc.	45	Washout, Plugs, etc.	77
	14	Guide Bar and Yoke.	46	Whistle.	78
Boiler Details.	15	Grate.	47		
Boiler Attachments.	16	Hand Rail and Foot Step, E.			
Box, Driving, Shoe and Wedge.	17	& T.	48		
Box, Engine and Tender Truck.	18	Feed Water Attachments.	49		
Brackets, Lamp Stands, &		Lagging.	50		
Ornaments.	19	Link Motion.	51		
Brake, Engine.	20	Lubrication.	52		
Brake, Tender.	21	Miscellaneous.	53		
Brake Equipment.	22	Preliminary Designs. Wheel			
Cab.	23	Base.	54		
Cock and Valve.	24		55		
	25	Piston and Rod.	56		
Crosshead.	26	Packing, Metallic, etc.	57		
Cylinder.	27	Pipes and Fittings.	58		
Cylinder Attachments	28	Reverse Lever.	59		
Cylinder, Compound Attach-		Rocker and Box, etc.	60		
ments.	29	Running Board, and Wheel			
Cylinder, By Pass and Relief		Covers.	61		
Valve.	30	Rod, Main, Side, etc.	62		
Draw Gear, Engine.	31	Safety Valve, Steam Gauge.			
Draw Gear, Tender.	32	Steam-Heat and Special Fittings.	63		
Eccentric and Strap.	33	Steam Chest.	64		
Engine Truck, Leading and		Superheater.	65		
Trailing.	34	Signal Equipment, Lamps,			
Erecting, Engine and Tender.	35	Flags, etc.	66		
	36	Smoke Box.	67		
Exhaust and Steam Pipe.	37	Springs, Engine and Tender.	68		
Expansion Brackets. Foot Plate.	38	Spring Gear.	69		
Fire Box Fittings.	39	Tools, Engine and Tender.	70		
Fastenings. Miscellaneous.	40	Tank and Coal Bunker.	71		
Frame, Main and Front.	41	Tender Frame.	72		
Frame Details, Main.	42	Tender Truck.	73		
Fuel, Oil Burners and Details.	43	Throttle and Dry Pipe.	74		

FIG. 3.—GROUPS, OR SUBDIVISIONS, OF LOCOMOTIVE AND TENDER DRAWINGS.

C—Cars.
D—Power plants.
E—Electrical
F—Frogs, switches and track material.
H—Buildings, water tanks, coal and ash handling plants.
K—Furnaces and forges.
L—Locomotives and tenders.
R—Cranes, hoists and traversers.
T—Machines and machine foundations
U—Office furniture.

These classes are subdivided into a large number of groups, each of which represents one or more of the details of the class in question. The number of subdivisions, of course, depends on the nature of the machine or appliance which the class represents; thus, the classification letter "L" which covers locomotives and tenders has 65 subdivisions, or groups, which are numbered consecutively from eleven to seventy-eight; each of the other classes are subdivided in a similar manner but owing to the simpler construction of the appliances and equipment represented, the number of groups is smaller.

The classification for locomotives and tenders, which has the largest number of groups, or subdivisions, is shown in Fig. 3. Each group is again subdivided to show the names of the detail parts in it, this being desirable both for locating the group to which any particular detail belongs, and also so that the parts will always be designated by the same name throughout the system; Fig. 4 shows the subdivision of groups 20 L to 23 L. Having a complete group classification, covering every subject which may come up, the numbering of any tracing and the recording of that number becomes a simple matter. The group number and classification letter always appear on the tracing

Group No.	Group Title.	Group Subdivision.
20	Brake, engine	Arrangement
		Details
		Beam
		Head and shoe
		Cylinder bracket
		Lever
		Hanger
		Rods
		Truck brake
		Details
21	Brake, tender	Arrangement
		Details
		Levers
		Beam
		Head and shoe
		Cylinder bracket
		Rods
		Hand brake
22	Brake equipment	Arrangements of valves, reservoirs, etc.
		Air reservoir, hanger and saddle
		Air pump
		Air signal
		Engineer's valve
		Brake piping
		Brake cylinder
23	Cab	Cab
		Details and furnishings
		Braces
		Corner iron
		Apron and hinge (lap plate)
		Arm rest
		Door fixtures
		Cab gong

FIG. 4.—SHOWING SUBDIVISIONS OF SOME OF THE GROUPS.

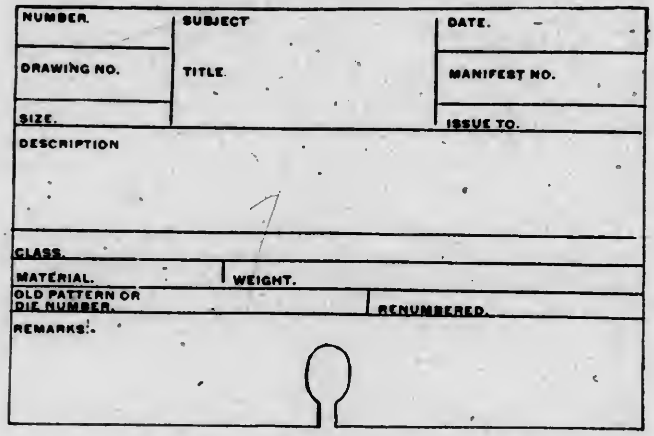


FIG. 5.—INDEX CARDS FOR DRAWINGS.

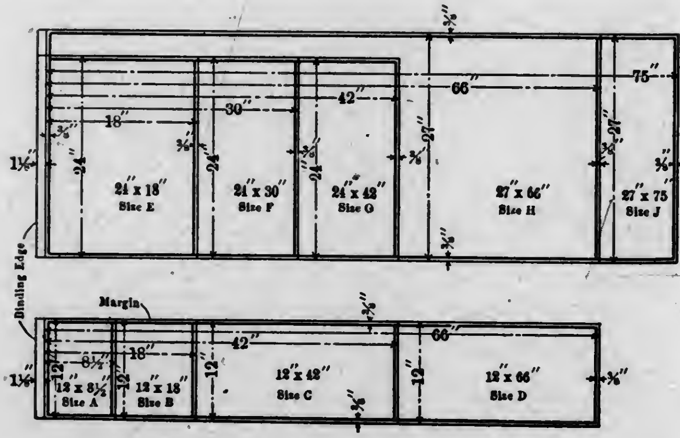


FIG. 6.—STANDARD SIZES OF TRACINGS.

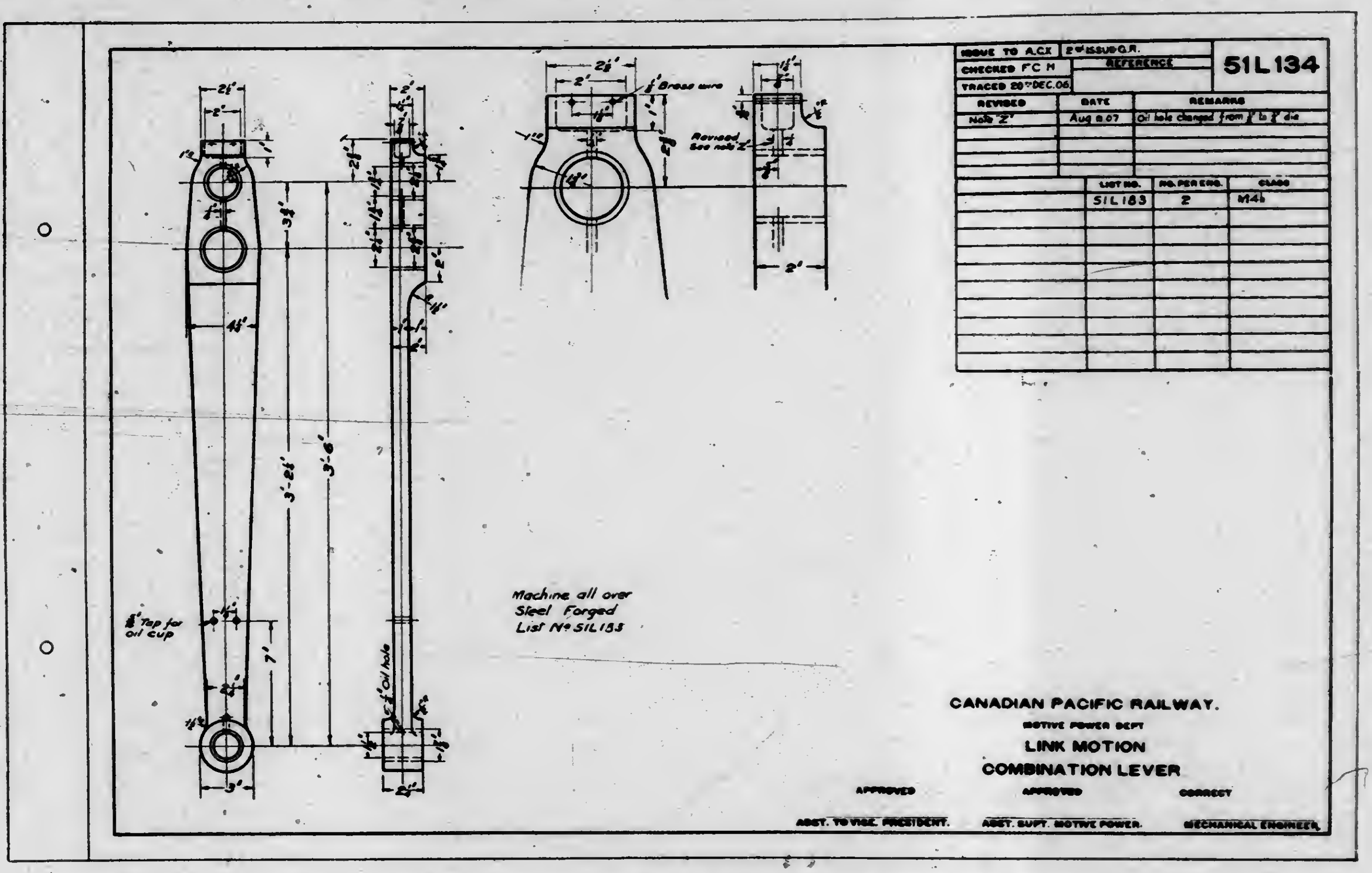


FIG. 7.—SHOWING THE ARRANGEMENT OF THE TITLE, ETC., OF ONE OF THE TRACINGS.

and form the first, or identification portion, of the number; the actual tracing numbers which run consecutively from one are written on the right of the classification letter and group number, thus, 20 L 1 represents the first engine brake drawing, 23 L 1 the first cab drawing, etc.

These numbers, with all other necessary information, are recorded on index cards, specially printed for the purpose, as shown by Fig. 5, the cards being arranged consecutively by groups in their trays, and may be readily referred to.

Sizes of Tracings.—Standard sizes for tracings vary from 12 x 18 in. for details to 27 x 75 in. for large elevations. These dimensions were determined largely by the size of the elevation drawing of a locomotive when laid down to 1½ in. scale, from which many of the more complicated parts, such as boiler, frames, etc., may be traced direct, thus avoiding the additional labor of redrawing them to a smaller scale. There is also an 8½ x 12 in. sheet which is used for pattern and other lists.

It will be seen from Fig. 6, which shows the sizes of tracings, that sheets B, C and D are 12 in. wide and sheets E, F and G are 24 in., or just twice as wide. This is so that blue prints made from sheets E, F and G may be folded once longitudinally, then inwardly so as to fit a 12 x 18 in. binder; sheets C and D are brought to this size by folding inwardly. Complete blue print sets of groups are made up in this way, both for issue and for ready reference in the office, thus saving the tracings from handling. The A size (8½ x 12 in.) is also a standard binder size.

File for Tracings.—Tracings are filed by groups in drawers, subdivided to fit the various sizes exactly, the outside of the drawer being labeled with the group number and size of the tracings contained in it.

Titles on Tracings.—A sample of the standard sheet (size B) is shown in Fig. 7. This size is used for all of the smaller details, one piece only being shown on each tracing. Titles and approvals are located in the lower right-hand corner. The third line of the title shows the name of the group to which the detail belongs, as listed in the group classification (Fig. 3). The fourth line shows the actual title or name of the part shown.

The number of the tracing, issue symbol, revision notice, and class of rolling stock or equipment on which the detail is used are shown in the upper right-hand corner. Provision is also made for tables, showing different lines, in which variation in dimensions may be entered to permit of the tracing being used for different classes of equipment, when this can be done without materially altering the outlines of the part shown. The issue symbol line is used in connection with a system for issuing blue prints to outside points and is fully described further on.

CANADIAN PACIFIC RAILWAY COMPANY
DRAWING OFFICE

PRINT REQUISITION ....190...

No...

DRAWING No.	TITLE	QUANTITY	KIND

DELIVER TO

....

Chief Draftsman

FIG. 8.—BLUE PRINT REQUISITION BLANK.

In case a tracing is made which supersedes some previous tracing, or if for any reason it is desirable to refer to any other record, the number of the tracing or record is filled in in the line reserved for "Reference" and forms a convenient means of identification. The revision notice column, in which is entered a short description of any change made on a tracing, has proven to be very useful, as it gives a positive record of the change and the date on which it was made. This can be done also by striking out the figures to be discarded, but this has the effect of spoiling the appearance of the tracing and may also be easily overlooked. Five lines are reserved for revisions, and

when these are filled the alterations will probably have changed the appearance of the detail to such an extent as to make a new tracing desirable.

Printing Titles.—All titles and reference headings and columns are printed in an 8 x 11 in. hand printing press, which is also used for circulars, regulations, miscellaneous forms, etc. As the amount of work done by this machine is quite extensive, and as there is also a large number of blue prints to be made daily, a small room convenient to the drawing office has been provided for this work.

To avoid delay to tracings, waiting to have titles printed on them, a schedule has been arranged by which the press will be used for this class of work between the hours of 11 and 12 A. M. and 4 and 5 P. M., at which times the tracings will be sent to the printer.

As a large amount of the work turned out in this printing office is for other departments, it became necessary to devise some means of checking the work done, and of insuring its delivery to the proper department; for this purpose the form shown in Fig. 8 is used—the tracings, circulars or forms, etc., which are to be printed, are handed to an order clerk who fills in the form, which is the printer's authority to proceed with the work; any explanations necessary are also noted on the slip. On completion, both prints and tracings are returned by the printer's messenger to the department owning them and the order form is returned to the clerk who checks it off.

CANADIAN PACIFIC RAILWAY COMPANY.

MOTIVE POWER DEPARTMENT.

SPECIFICATION No. 5 L S 1.

SPECIFICATION FOR BABBITT METAL.

No. 1 BABBITT METAL. To consist of 87 per cent. tin, 7¾ per cent. copper, 5¼ per cent. antimony, and must contain within one-half of one per cent. of the antimony specified.

No. 2 BABBITT METAL. To consist of 6½ per cent. tin, ½ per cent. copper, 14 per cent. antimony, 79 per cent. lead, and must contain within one per cent. of the antimony specified.

No. 5 BABBITT METAL. To consist of 8⅓ per cent. tin, 8⅓ per cent. antimony, 83⅓ per cent. lead, and must contain within one-half of one per cent. of the antimony specified.

No. 6 BABBITT METAL. To consist of 2 per cent. tin, 14 per cent. antimony, 84 per cent. lead, and must contain within one per cent. of the antimony specified.

No. 7 BABBITT METAL. To consist of ½ per cent. copper, 19½ per cent. antimony, 80 per cent. lead, and must contain as near as possible the exact amounts of the antimony and copper specified.

No. 8 BABBITT METAL. To consist of 5 per cent. tin, 3 per cent. antimony, 92 per cent. lead, and must contain within one-half of one per cent. of the antimony specified.

No. 9 BABBITT METAL. To consist of 40 per cent. lead, 59 per cent. copper, 1 per cent. tin.—U. S. Experimental Packing Superheater Engines.

All Babbitts must not contain more than one-quarter of one per cent. of total impurities, and must contain full amount of tin when it is specified.

Correct. Approved.

A. W. HORSEY, Mechanical Engineer. H. H. VAUGHAN, Asst. to Vice-President.

MONTREAL, AUGUST 9, 1905.

FIG. 9.—GENERAL FORM OF THE SPECIFICATION SHEETS.

Blue Printing.—Blue printing is done entirely by artificial light. An electric machine of the rotary type fitted with mercury tube electric lights is used. It is capable of printing 700 sq. ft. per hour, which suffices for present needs. A very convenient way of reproducing a tracing on which some revision is to be made, is as follows: A negative print on thin Vandyke (brown process) paper is first made, and if a revision is desired, the parts affected are painted out with India ink; the negative is then rendered transparent by means of a light application of paraffine applied with an electric or ordinary flat iron; a positive print is then made on Vandyke cloth from the prepared negative which gives a durable print in brown lines on a white ground. Any parts previously painted out may now be redrawn correctly on the cloth print which, if paraffined, may be blue printed in a similar manner to a tracing.

Specifications.—The group system of classification, as adopted for drawings, is also used for classifying and filing specifications, but as there is a comparatively small number of these in use at present, and very few are added, it has not been found necessary to use so many groups. The classification letters used for drawings are used for specifications and indicate the same subject. The letter "S" has, however, been added to distinguish between them. The grouping of the specifications for locomotives is as follows:

1 L S.—Specifications for building locomotives, and tenders and locomotive boilers.
2 L S.—Boiler material.
3 L S.—Steel, malleable and brass castings, axles, billets, etc.
4 L S.—Electrical equipment for locomotives.
5 L S.—Babbitt and bearing metals.

These general groups cover all the necessary specifications for locomotives and tenders, other equipment being provided for in a similar manner.

The numbering is similar to that for tracings, each group being numbered consecutively, starting at one. The first locomotive building specification is thus 1 L S 1. These numbers are recorded on index cards, together with other information describing the specification. All specifications are printed on standard letter size sheets 8 x 11½ in. in the small printing press used for titles; the general form of these specifications is shown by Fig. 9.

Foreign Blue Prints.—The system of classifying and filing foreign blue prints makes use of exactly the same classifications and grouping as used for drawings, except that the letter F, indicating a file print, is added; the first foreign locomotive ashpan print filed was, therefore, numbered 11 L F 1, the first car print 11 C F 1, etc.

Under this system each foreign print filed is given a definite record number, which is plainly written on a small cardboard disc attached to it by means of a string, passed through an eyelet. The print is then rolled and placed in its proper group in a pigeon hole file, the discs bearing the record numbers being plainly visible. These numbers are recorded on index cards, arranged by group together with all other information necessary to identify the print which, when wanted, is located by referring to the proper group in the card index, and the number being obtained the print is readily found by means of the disc bearing a similar number.

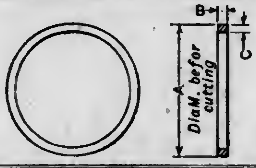
Patterns and Forgings.—The system of classifying and numbering patterns and forgings is the same as that in use for drawings; the same series of numbers is used and no attempt is made to distinguish between them; at first thought this may appear confusing but exactly the reverse is the case, it having proved one of the most simple and convenient parts of the whole system and from it has been worked out a method of listing patterns and standard material for distribution to repair shops by which replacement parts can be accurately ordered by list number; this is described and illustrated further on.

The record of patterns and these list numbers is kept in the same index as used for tracings, the same cards (Fig. 5) being used. Under the heading "Number" the pattern or list number is written; the number of the tracing on which it appears is written in the space immediately underneath headed "Drawing Number."

In the case of a card which is filled out for a tracing record only, both these spaces will show the same number, it being necessary to show consecutive numbers in the top space to insure the cards being placed properly in their trays. All the other spaces shown are not necessarily filled in; as these are combination cards certain headings apply only to tracings and *vice versa*.

By means of this classification, reference to the index card for any given pattern or list number, shows at once full informa-

PISTON RINGS



LIST NO.	CYL. DIAM.	A	B	C	LIST NO.	CYL. DIAM.	A	B	C	LIST NO.	CYL. DIAM.	A	B	C
56L201	17"	17 3/8"	3/4"	9/16"	56L33	18 3/8"	18 3/4"	3/4"	5/8"	56L65	20 1/8"	20 5/8"	3/4"	5/8"
56L202	"	"	13/16"	"	56L34	"	"	13/16"	"	56L66	"	"	13/16"	"
56L203	"	"	7/8"	"	56L35	"	"	7/8"	"	56L67	"	"	7/8"	"
56L204	"	"	15/16"	"	56L36	"	"	15/16"	"	56L68	"	"	15/16"	"
56L205	17 1/8"	17 1/2"	3/4"	"	56L37					56L69	20 1/4"	20 3/4"	3/4"	"
56L206	"	"	13/16"	"	56L38					56L70	"	"	13/16"	"
56L207	"	"	7/8"	"	56L39					56L71	"	"	7/8"	"
56L208	"	"	15/16"	"	56L40					56L72	"	"	15/16"	"
56L23	"	"	7/8"	"	56L55	"	"	7/8"	"	56L87	"	"	7/8"	"
56L24	"	"	15/16"	"	56L56	"	"	15/16	"	56L88	"	"	15/16"	"
56L25	18 1/8"	18 1/2"	3/4"	5/8"	56L57					56L89	22 1/8"	22 5/8"	3/4"	3/4"
56L26	"	"	13/16"	"	56L58					56L90	"	"	13/16"	"
56L27	"	"	7/8"	"	56L59					56L91	"	"	7/8"	"
56L28	"	"	15/16"	"	56L60					56L92	"	"	15/16"	"
56L29	18 1/4"	18 5/8"	3/4"	5/8"	56L61	20"	20 1/2"	3/4"	5/8"	56L93	22 1/4"	22 3/4"	3/4"	3/4"
56L30	"	"	13/16"	"	56L62	"	"	13/16"	"	56L94	"	"	13/16"	"
56L31	"	"	7/8"	"	56L63	"	"	7/8"	"	56L95	"	"	7/8"	"
56L32	"	"	15/16"	"	56L64	"	"	15/16"	"	56L96	"	"	15/16"	"

To order material from this list give number required and list number.

MANUFACTURED MATERIAL LIST SHEET NO. 1 GROUP 56.

FIG. 11.—A "MANUFACTURED MATERIAL" LIST.

tion about it, such as equipment to which it is applied, weight, material and the tracing number on which it is shown. This system also works well with the pattern stores, it being possible to locate a pattern almost instantly by means of its group number; it is also advantageous to have all patterns of the same kind in one rack.

One of the most important functions of a railroad drawing office is that of issuing information to the shops and motive power operating officials at distant points on the road, such as pattern and repair material lists, maintenance regulations, information regarding improvements and changes which are to be made at the division or main shops, etc. In the case of pattern and material lists, no great difficulty will be experienced in issuing them in some form or other, but to insure that they will be kept up to date, owing to additional equipment coming to the road and changes to that already in service, is a much more difficult problem; the system adopted must be one which, while placing full information in the hands of those requiring it, will also lend itself readily to adjustment and additions without undue labor and expense.

A standard pattern catalog sheet is shown in Fig. 10 and contains practically all the information necessary both as an office reference and a means of ordering repair castings. These lists are printed on 8½ x 12 in. (size A) tracing linen sheets by the 8 x 11 in. printing press, leaving only the information to be filled in. Prints are then made from them and issued to both the motive power and stores departments. Binders have been supplied to all receiving these lists and they are kept in book form, arranged by group and sheet numbers, which are shown in the lower right-hand corner.

Alterations and additions are made to this list by means of printed slips of exactly the same size as the line to be changed, but which show the alteration or addition and are pasted across the original record. The corrections are made on tracing linen, each line to be corrected being repeated ten or more times, depending on the number required; prints are then made, the lines cut apart and issued to all having books.

Manufactured Material Lists.—Lists showing repair material, such as rod knuckle pins, piston rings, axles and all other standard parts which are constantly requiring renewing, owing to wear, are gotten up and issued in much the same way as a manufacturer, making a standard article, does with his catalog, in which each piece comprising the completed article is usually designated by a number.

These standard repair parts are manufactured, and a limited amount for immediate shipment kept in stock at the Angus Shops, which is the main construction and repair plant of the Canadian Pacific Railway, material being sent from there to all parts of a system comprising over ten thousand miles of track. These "Manufactured Material" lists are made up and issued in a similar manner to the pattern catalog, each piece shown being designated by a list number which is all that need be mentioned when material is ordered, as the detail drawings showing these parts are listed in a like manner. The classification of the equip-

PATTERN CATALOGUE

C. P. RY. LOCOMOTIVE CASTINGS

LINE	DESCRIPTION AND WHERE USED		PATTERN NO.	MATERIAL	WEIGHT LBS.	WEIGHT OZ.	DRG. NO.	PATT MADE
1	CYLINDER COCK BODY-STANDARD		30L95	M.I	–	14	30L94	
2								
3								
4	CYLINDER COCK SHAFT BRACKET (ON FRAME)							
5								
6	D4e		30L211	C.I.	8	12	30L126	X
7	D6a.		30L71	C.I	24	9	30L172	X
8	D9ab.		30L71	C.I.	24	9	30L70	X
9	D10abcd-D11-M4-U8	R. HAND	30L53	C.I.	20	–	30L52	X
10	D10abcd-D11-M4-U8	L. HAND	30L54	C.I	20	–	"	X
11	E5f	R. HAND	30L166	C.I.	14	–	30L164	X
12	E5f	L. HAND	30L167	C.I.	14	–	30L165	X
38								
39	CYLINDER COCK OPERATING HANDLE BRACK'T							
40								
41	C1ea-C2a-D2a-D3bcdhj-D5b.		30L210	C.I.	4	5	30L154	X
42	D4abcd-D6bcd-E2fde-F1ab		"	"	"	"	"	X
43	D3a-ENG 820-J2ac-L2b-L4c-M1ab		"	"	"	"	"	X
44	M2ab-U2abcdef-U3ac		"	"	"	"	"	X
45								
46	D9a		30L236	C.I.	1	13	30L170	X
47								
48	D6a-D9b-D10abc-D11-E5gf-G1abcd		30L67	C.I.	1	14	30L49	X
49	G2abcd-M3-M4-U8.		"		"	"	"	X
50								

ABBRIVIATIONS: C. I., CAST IRON; M. I., MALLEABLE IRON; C. S., CAST STEEL; BR., BRASS; BZ., BRONZE
X INDICATES PATTERN HAS BEEN MADE.

GROUP 30 SHEET 7

FIG. 10.—PATTERN CATALOGUE SHEET.

SIDE ROD KNUCKLE PINS

LIST NO.	DESCRIPTION	CLASS
62L156	For New Work.	L3
62L157	For Repairs.	
62L158	For New Work	U2ef
62L159	For Repairs	
62L160	For New Work	L4c
62L161	For Repairs	
62L162	For New Work	C2a; D3j; D4; D5; D6bcd; E4; E5ab.
62L163	For Repairs	
62L185	For Repairs	
62L186	For New Work	D10; D11; G1; G2; M4.
62L187	For Repairs	
62L188	For New Work	L4ab
62L189	For Repairs	
62L190	For New Work	U3c
62L191	For Repairs	
62L192	For New Work	L5a; M1; M2.
62L193	For Repairs	
62L194	For New Work	E1; E2abc; J2.
62L195	For Repairs	
62L196	For New Work	L1ab.
62L197	For Repairs	
62L198	For New Work	U1a.

To order material from this list give number required and list number.

MANUFACTURED MATERIAL LIST SHEET NO 1 GROUP 62.

FIG. 12.—A "MANUFACTURED MATERIAL" LIST.

ment using the parts is also given, except in the case of material which is standard for all classes.

Representative sheets of each are shown in Figs. 11 and 12, the former showing piston rings which are made to suit both new and worn cylinders, in diameters advancing by one-eighth inch through a range which covers all sizes in use, and the latter showing the list numbers of knuckle pins which are similarly made for new and repair work for different classes of locomotives. The detail drawing of one of these pins is reproduced in Fig. 13 and shows the manner in which those for repairs are sent out, leaving only the rod fits to be finished at the division shops, where the cost is higher than at the main shop, owing to less complete facilities.

A list of this kind bound in loose-leaf book style is much more convenient and useful in the ordinary roundhouse than a set of prints; also, being arranged by group, it is practically self-indexing and contains in an easily accessible form the information necessary to order material for all sorts of running repairs.

These lists are adaptable to practically every part of a locomotive and are equally valuable both as a shop and office record, as each group listed contains in condensed form all of the details shown on hundreds of drawings, which is invaluable in lo-

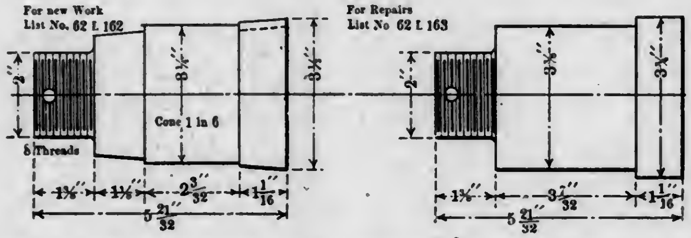


FIG. 13.—DETAIL DRAWING OF KNUCKLE PIN SHOWING DIFFERENCE IN FINISH FOR NEW AND REPAIR WORK.

cating existing patterns, and forgings for which dies have been made, in working up designs for new equipment. When these lists are being worked up, careful attention is paid to standardizing all parts possible and the number of parts which are found to differ so slightly as to be made interchangeable with some minor alteration is surprising. This is especially noticeable when working up cocks and valves, oil cups and other brass details, it being possible to sometimes cut the number of patterns carried by one-half with a resultant large decrease in the amount of repair material to be carried in stock by the stores department.

Another important advantage of this system is the ease and directness by which repair parts may be ordered from points hundreds of miles distant, either by wire or stores requisition. For example, a locomotive foreman finds that he will soon need to renew certain parts of a locomotive; he refers to his material list, locates the parts in question by means of the group numbers and places his order for the quantity, simply mentioning the list number. This does away with all confusion through different names being given to the same detail and having to turn over a lot of records to find a drawing of the part wanted, as in the case when orders are placed by means of the engine number. The order being received by the stores, the part wanted can be immediately located by its list number, if it is a stock article; if not, an order being placed on the main shop, the necessary information to do the work is forthcoming by reference to the "Manufactured Material" list which, if it does not give all the information required, refers to the drawing from which it may be obtained.

A further advantage of this system is that "New" and "Repair" parts may be listed, the former being exactly to the original size when the engine was new and the latter to correspond to a certain degree of wear, such as takes place in cylinders and pistons, rod brasses, etc. This is illustrated by the piston ring "Manufactured Material" sheet, shown in Fig. 11, on which are shown repair rings advancing in diameter by one-eighth inch and in thickness by one-sixteenth inch.

(To be continued.)

A REINFORCED FLUE SHEET.

By W. H. Lewis.*

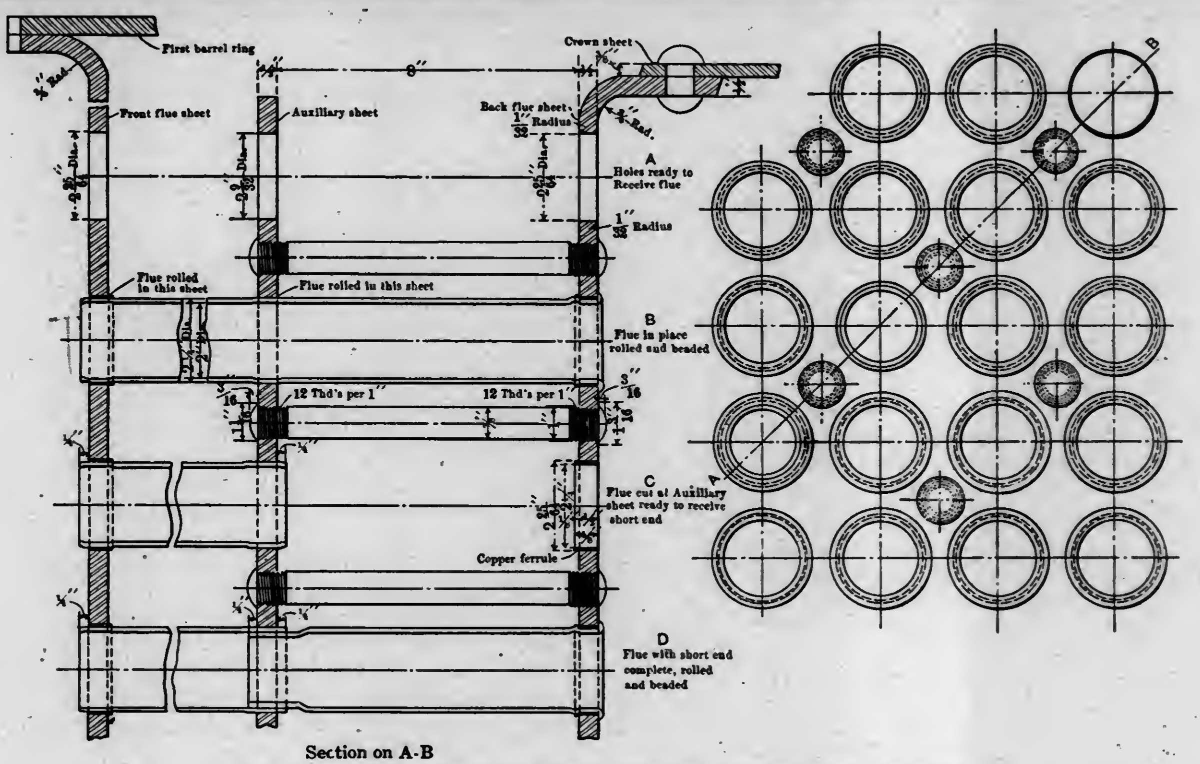
The two-part flue, as it will be termed for convenience, has a three-fold object: first, trussing or reinforcing the back flue sheet against bulging; secondly, improving the circulation in the vicinity of the back flue sheet by the formation of a channel between it and the reinforcing sheet; and thirdly, permitting the use of a detached safe end; the latter, however, when in place forming an integral part of the flue. The essential features of the apparatus are quite simple, requiring practically no alteration in the flue sheet except the additional or reinforcing sheet, approximately the same thickness or a little heavier, which is carried on staybolts 8 inches ahead of and parallel to the back flue sheet to which it is attached. In the applications so far made, the flues have been placed in vertical rows, which seems to lend itself very well to the introduction of the short spacing between staybolts holding the reinforcing sheet, but the arrangement does not necessarily preclude the diagonal spacing of the flues should that be desired.

The accompanying illustration shows the sheet as it has been attached to the firebox flue sheet of a consolidation freight engine; cylinders 21 x 30 in.; weight on drivers, 168,000 lbs.; tractive effort, 40,173 lbs.; grate area, 45 sq. ft.; firebox heating surface, 173 sq. ft.; flue heating surface, 2,778 sq. ft., and total heating surface, 2,951 sq. ft. There are 258—2¼" flues placed in vertical rows, 3⅛" pitch, which allows a bridge space between adjacent flues of ¾". In the center of the rectangle formed by every four adjacent flues, a staybolt to hold the reinforcing sheet is placed, which bolts thus form the corners of another rectangle. These bolts, therefore, are also in vertical rows 3⅛" apart the same as the flues and do not reduce the bridge between the flues, as it is customarily termed. These spacing bolts measure ⅞" at the center and are threaded at either end where they enter the back flue sheet, as well as the reinforcing sheet, and are riveted over at either end. In the earlier application these bolts were threaded into the two sheets similar to the present design and as shown in drawing, but had button heads on the fire side of the flue sheet. At the other end attaching to the reinforcing sheet the threaded portion was somewhat smaller than the body of the bolt and turned back sufficiently to provide a shoulder against which the auxiliary sheet was drawn and double nutted. But observations led to the idea that by reason of the possible retention of heat in the amount of material in the head, the life of adjacent flues was impaired; hence the adoption of the head similar to the ordinary staybolt. The same form of head has proven to be equally satisfactory where attachment is made to the reinforcing sheet. This latter sheet, swung as it is parallel to the flue sheet, necessarily has the flue holes drilled coincident with that sheet; in fact, to accomplish this, the reinforcing sheets have been bolted to the back flue sheet and the drilling done simultaneously to insure accuracy.

The body or longer portion of the flue extends from the reinforcing sheet to the front flue sheet, through each and ¼" beyond, as will be seen in the illustration. In the front flue sheet the copper ferrule has been used, but in the back sheet it has not been introduced. After this longer portion of the flue is put in place and is securely rolled in the two sheets, nothing more need be done to it. The short detached safe end, as we may properly term it, after being cut to the proper length and swaged to slip inside of the flue already rolled in the reinforcing sheet, is thoroughly annealed, then driven into place and rolled in the flue in the reinforcing sheet, making a tight telescopic joint. This is all the work that end of the safe end receives. The end entering the firebox sheet is expanded, prossered and beaded, completing the application.

The object of the reinforcing sheet, as stated, was to support the flue sheet against bulging, and in the first applications the flues were in one piece from back to front flue sheets in the customary way, but securely rolled in the reinforcing sheet through

* Superintendent of Motive Power, Norfolk and Western Railway.



Section on A-B

DETAILS OF REINFORCED FLUE SHEET—NORFOLK AND WESTERN RAILWAY.

which they passed. This anchoring of the flue in the reinforcing sheet, it was confidently thought, would act as a support for the joint and bead in the back flue sheet. There is no question but that this has been realized, as engines have been allowed to run until the beads have entirely wasted away; in fact, the end of the flue has burnt down to practically a knife edge and flush with the firebox side of the flue sheet, still holding securely and leaking but very little, if any, more than some of the flues with comparatively good beads.

It was when these engines were first handled through the shop for renewals of flues that the idea suggested itself that the flue could be cut off between the back flue sheet and the reinforcing sheet and a short end swaged, driven into and rolled, obtaining to all intents and purposes a new safe end without further disturbance to the balance of the flue reaching from the reinforcing sheet forward. In the original design it was contemplated using a detached end differing only to the extent of using a butt joint in the auxiliary sheet; the telescopic joint, however, seems to answer the purpose and fully accomplish what was intended.

The prevention of bulging of the flue sheet also seems to have been accomplished as none of the engines so far equipped have developed any indications of this trouble. Having given this additional stability to the back flue sheet, the consideration of the practicability of using a thinner flue sheet is claimed and it would seem perfectly feasible to thin the flue sheet down to at least 3/8", making the reinforcing sheet, say, 5/8" or 3/4", so as to carry the major portion of the load.

The studies of the problem would seem to show that while a great deal depends upon the initial workmanship in the application, and the material must also be given due consideration, the fact remains that the water has a powerful influence. Where there is any perceptible deposit on the flue sheet, or adjacent to the flue joint, the amount of material through which the heat must penetrate directly increases the severity and consequent destruction to the bead and flue sheet joint. Therefore by thinning down the flue sheet the conditions for retention or dissipation of the heat are in the first place improved to that extent.

The next development, and the results thus far seem very promising, is to simply roll the safe end in the back flue sheet, allowing the end of a flue to come out flush, making no attempt whatever to bead over since there is no pressure on the safe end except in the direction of collapsing. Leaving the copper ferrule out of the back flue sheet as well, would not seem to be a bad practice, although in the experiments where the beads have been left off the copper has not suffered perceptibly by exposure. It is a curious fact that in the experiments where the detached ends have been put in the same engine with, and without beads, the beads have uniformly burnt off and wasted away while those without beads, though they protrude about 1/8" beyond the face of the sheet, have not undergone any noticeable deterioration. Apparently the leaking has been largely confined to the beaded flues, which might possibly be explained by excessive working, which in the nature of things must be done cold, resulting in hardening the material, thus making it more brittle and susceptible to splitting and otherwise breaking down. To date, there are 90 engines equipped with this detached safe end, although none of them were so equipped originally, it being done as engines were handled through the shop for flue renewals. These applications have been made uniformly for the past year, and up to the present time no cases of the telescopic joint leaking have been found. This joint, therefore, proving to be entirely reliable, carries with it the freedom from whatever uncertainty has surrounded the lap or butt-welded safe end.

The flue mileage appears to show that the bead on the detached end fares the same as those on the ordinary flue; therefore, the net gain lies in the saving in time and labor in the renewal of the safe ends where the beads have worn off and wasted away, whereas it would otherwise have entailed the removal of the entire set of flues, disturbing, at no inconsiderable cost, the steam pipes in the smokebox, and draft appurtenances in order to cut and reweld the safe ends. These benefits very obviously obtain since the removal of the short detached safe ends involves simply their removal, approximating not over one-half of what it would ordinarily cost to remove the full set of flues. In bad water districts where the deposit is excessive there might be reason for the removal of the entire set of flues at shorter periods, but ordinarily the flue beads waste away before the flues should necessarily come out to be cleaned. This removal of the beaded end makes it possible to quickly overhaul the flues, restoring them to good order, very probably handling the work to an advantage in the roundhouse instead of taking the engine out of service for a longer period. In localities where the flues largely determine the mileage between shopping, it would seem perfectly feasible to maintain the flue renewals at the roundhouse, keeping the engine in practically continuous service until the machinery is completely worn out, provided the renewal of tires can also be handled at the round-house.

BETTERMENT WORK IN THE CAR DEPARTMENT.

Atchison, Topeka & Santa Fe Railway.

By J. E. Epler.*

Although a number of articles † have appeared in the American Engineer concerning betterment methods on the Santa Fe, very little has been said concerning the details of this work in the car department. Work was started in this department in May, 1906. Some of the methods followed have been in use, to a greater or less extent, on a number of roads in this country. These were extended and followed up so as to secure the co-operation of both the men and the foremen in securing results. No changes were made until all interested were enlightened; to keep up interest each person affected was, if necessary, shown his progress daily. If minimum costs are sought, each man concerned should know what share his department is bearing and whether or not reductions are actually being made.

Past experience indicates that one of the principal reasons for expensive shop methods has been ignorance of the foremen, and even master mechanics, of the cost of operating their departments. Very few foremen know the monthly payroll of their shops. With the introduction of the clock and block systems, the timekeeping passed from the hands of the foremen to timekeepers in the master mechanic's office, or in a great many cases to the motive power accountant, and the foreman's knowledge of his payrolls ceased. Sometimes master mechanics and foremen are furnished with statements showing the total of their payrolls, but almost invariably when it is too late to make any improvement. Every master mechanic and foreman should know what each department under his jurisdiction is costing—not monthly, but daily. He should also know the amount of work accomplished for the money expended. Simple statements showing him just what has been done are often equal, if not superior to, additional help.

Method of Making Freight Car Repairs.

First attempts at improvement were made in the freight car repair yards. Repair schedules were made giving standard times‡ for the various operations in repairing cars; to simplify the work required of shop inspectors and timekeepers a card was devised for keeping a record of repairs made to a car and the time required for these repairs. The face side (see illustration) is used by the yard inspector in bad ordering the car. Switchmen are notified where to place the car by the position of the card; placed vertically, the car goes to the light repair yard; horizontally, to the heavy repair yard. At this place, the main defects shown on the card give the repair yard foreman sufficient knowledge for a further placement of the car, a very important matter in heavy repairs, as repaired cars are often blocked for days and extra work is entailed by careless placing of other cars requiring heavier repairs.

When the car is placed, the time is noted and a shop inspector removes the card and gives the car a thorough inspection. He notes all defects found on the reverse side of the card (see illustration) and replaces it on the car, reverse side out. The time-

Std. Time C. R. 40.15 hr. Std. Time Carp. .... hr.

No. of Pieces	Schedule No.	DEFECTS		Standard Time
1	435	Side sill		25.
2	546	Draft timbers	B	9.
1	101	Coupler	"	1.
1	25	Buffer block	"	1.
1'	508	Side siding (sill side		.3
5'	509	Side siding " "		.75
20'	208	Side lining		.8
		TRUCKS.		
1	638	Pair wheels	B	1.2
1	590	Metal brake beam	"	.5
2	624	Brake shoes	A	.2
2	79	Bottom C-plate bolts		.4
				40.15

NAME	DATE	Time on	Time off	Time on	Time off	Total Time
G. Cokes	1/22	8	5			8
D. Miles	"	"	"			8
G. Cokes	1/23	7	6			10
D. Miles	"	"	"			10
						36

REVERSE SIDE OF BAD ORDER CAR.

keeper follows and places the time allowed by his schedule on the card. Repairmen are then assigned to the car. They sign their names and register the time in a space provided for this purpose. When the car is finished the men record the time of completion. It is then re-inspected to determine the quality of work and whether all repairs ordered on the card have been made. The O. K. time is noted, and this, together with the record of the time of placement on the repair track, has relieved many an embarrassing situation for the foreman; it forms an important part of his card record.

The card is then sent to the car foreman's office, where the

* Bonus Expert, Cleburne, Texas.

† Previous articles which have been published in this Journal concerning betterment work on the Santa Fe are as follows:

"Shop Betterment and the Individual Effort Method of Profit Sharing," by Harrington Emerson. (A reprint of a pamphlet which was prepared for distribution among the workmen on the Santa Fe.)—Feb., '06, page 61.

"Locomotive Repair Schedules," by C. J. Morrison. (A detailed description of the schedules in use at the Topeka shops.)—Sept., '06, page 338.

"The Surcharge Problem," by C. J. Morrison. (A description of the method of determining surcharges and how they are applied.)—Oct., '06, page 376. Communications concerning this article were published on page 438 of the Nov., '06, issue, and 478 of the Dec., '06 issue, Mr. Morrison going into greater detail as to the exact methods of determining the surcharge on page 479. Other communications appeared on page 64 of the Feb., '07, issue.

"Betterment Work on the Santa Fe." (A complete study of the development of this work and the general and specific results which had been obtained to date. The article covered 26 pages.)—Dec., '06, page 451. Communications concerning this article appeared in the Feb., '07, issue, page 63, and March, '07, page 102.

"Dispatching Board for Engine Repairs," by C. J. Morrison.—Apr., '07, page 131.

"Roundhouse Betterment Work," by J. F. Whitford.—June, '07, page 216.

"The Methods of Exact Measurement Applied to Individual and Shop Efficiencies at the Topeka Shops," by Harrington Emerson.—June, '07, page 221. Communications concerning this article appeared on pages 287 of the July, '07, issue, and 308 of the August issue.

"Shop Cost Systems and the Effect of Shop Schedules Upon Output and Cost of Locomotive Repairs," by A. Lovell. (A reprint of a paper presented before the Master Mechanics' Association and an abstract of the discussion. —July, '07, page 274.

"Shop Efficiency," by H. W. Jacobs. (A study of the individual and shop efficiency methods.)

"Wastes at Fuel Stations," "Reports in Connection With the Operation of Fuel Stations," and "Fuel Performance Records," on pages 134 and 140 of the April, 1908, issue, in connection with an article on "Locomotive Fuel Economy."

"General Tool System," page 239 of this issue. A description of the methods of improving the efficiency and caring for the tool equipment over the system.

"The Solution of the Crank Axle Problem," by Howard H. Lanning, page 218, this issue.

Editorial comments on the betterment work on the Santa Fe appeared on page 478 of the Dec., '06, issue; page 20 of the Jan., '07, issue, page 231 of the June, '07, issue, page 395 of the Oct., '07, issue.

‡ These standard times were determined after careful time studies, similar to those made in the locomotive department, as described in previous articles.

Form 1203 Standard. Hall 3 08 50M 0000

Santa Fe.

Initial A. T. & S. F. Class Box Date 1/18/08.

BAD ORDER

CAR No.

Sent to CLEBURNE Shops. Time placed 7. a.m. 1-22 p.m.

Loaded ~~Empty.~~ Time repaired 1-23 ~~a.m.~~ 6 p.m.

Defects Side sills and Draft timbers broken.

C. George. Inspector at Temple

BAD ORDER CARD—SANTA FE.

timekeeper draws off on a bonus card for each man, his part of the time allowed to repair the car and the time actually taken. The comparison of the total of these times at the end of the month determines a man's efficiency and his bonus. The car number being drawn off also, a record is available of the cars repaired by each man, furnishing a ready check of the work done by any man from start to finish.

The bad order card finally is filed according to the last two numbers of the car and remains as a permanent record of all repairs

STANDINGS OF BONUS CLASS. __________ DIV.

NAME	TITLE / RATE	LOCATION	DATE / GRADE	DATE / GRADE	DATE / GRADE	DATE / GRADE	DATE / GRADE	DATE / GRADE	DATE / GRADE	DATE / GRADE
ABBOT, GEO.	B.T.K	CLEB.	1-14-08	1-17-08	1-24-08	1-31-08	2-7-08	2-14-08	2-21-08	2-28-08
	75.00		100	95	97	38	92	76	88	98
BAIRD, G. O	B.T.K.	CLEB.	1-14-08	1-17-08	1-24-08	1-31-08	2-7-08	2-14-08	2-21-08	2-28-08
	75.00		94	71	69	63	94	90	100	100
BORACK, W.	B.T.K	CLEB.	1-14-08	1-17-08	1-24-08	1-31-08	2-7-08	2-14-08	2-21-08	2-28-08
	85.00		100	98	ABS.	99	ABS	87	9.2	100
DARNWELL, H.	B.T.K.	TEM.	1-14-08	1-17-08	1-24-08	1-31-08	2-7-08	2-14-08	2-21-08	2-28-08
	75.00		13	67	70	82	99	100	98	71
WATERS, H. M.	B.T.K.	GALV.	1-14-08	1-17-08	1-24-08	1-31-08	2-7-08	2-14-08	2-21-08	2-28-08
	60.00		36	75	90	85	99	84	80	91
LUNDBERG, C.	FOREMAN	CLEB.	1-14-08	1-17-08	1-24-08	1-31-08	2-7-08	2-14-08	2-21-08	2-28-08
	90.00		100	82	94	98	71	84	100	98

RECORDS OF EXAMINATIONS OF BONUS TIMEKEEPERS.

made. This card eliminates shop inspector's records and also the foreman's office record of cars repaired, which is usually copied by a clerk from the repair yard inspector's record. The older records were not always complete. Repairs other than those which at first appear necessary often develop, and under the old method the workmen were simply told to make these. Now they are allowed time for repairs shown on repair cards and no one but the inspector or timekeeper is allowed to take from or add to the original; thus all repairs are necessarily recorded.

In addition, the cards being placed on the side of the car enables the foreman at any time to see how the men are progressing and to estimate when he may expect the work to be completed. He is not compelled to take the man's word for the amount of work done, or the time consumed. He can, at a glance, see just what the work is, and whether or not the men are working efficiently. The workmen have not the complaint, sometimes made, that they do work for which they are allowed neither time nor pay.

BONUS SCHEDULES—EDUCATION OF TIMEKEEPERS AND INSPECTORS.

In the administration of bonus or piece work schedules, a prolific source of trouble lies with the timekeepers and inspectors. These men control the making or marring of the success of the schedule. Not enough attention has been paid to them. As a rule they have been given schedules to install and left to work out their own salvation. Bonus or piece work schedules are like all books of rules, capable of being interpreted as the individual opinion dictates. Left to himself the timekeeper, being in contact with the workman, will, when called upon to give a decision, not being certain (through ignorance), usually side with the workman. Even if when starting the bonus, all timekeepers are carefully drilled, there still exists the uncertainty that they may either quit and other men take their places, or they may forget their first instructions. To obviate this trouble and secure a uniform method of applying the schedule and timekeeping, weekly examinations are held. A list of test questions is sent to every timekeeper, which he answers and returns to the bonus supervisor for correction. The corrected paper is returned to him. From his examination the timekeeper is rated and a card form, as shown in one of the illustrations, is kept in the supervisor's office showing the standing of each man.

Men who fall below 85 per cent. are either removed, or placed with other timekeepers and given the opportunity to learn. At the main shops weekly classes are held, which timekeepers and foremen attend; any workmen desiring to fit themselves for promotion are given examination papers, similar to those for the timekeepers. These men make good emergency timekeepers and are given preference when a vacancy occurs. At these classes the questions of the examination are thoroughly gone over and all points made clear, also any questions are answered that may have arisen during the week regarding the application of a schedule.

The result is that there are now few irregularities in the correct interpretation of schedules and there is a remarkable uniformity in their application. The foremen know as much about the schedules as the timekeepers themselves and can answer the questions of the workmen without referring to the timekeeper. They know at once whether men are being justly treated and this gives a double check on the work. Inasmuch as men, as a rule, do wrong through ignorance, one can feel fairly certain

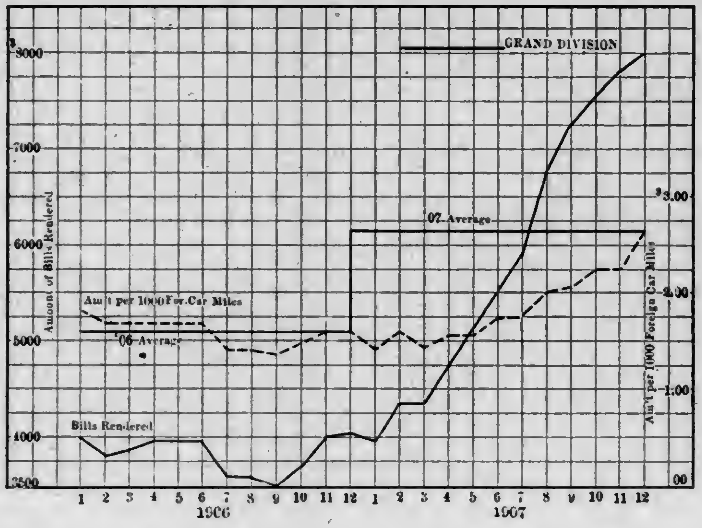
Hall 7 07 10M 6420 Form 2202 Standard.

BONUS TIME RECORD, CAR DEPT. MO. JAN YR. 1908

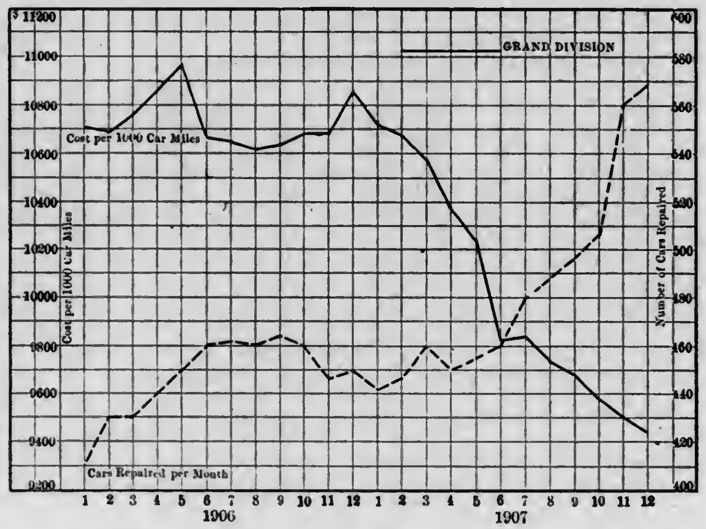
NAME Cox, J. C. No. 1301 ACT. TIME 234 STD. TIME 273.1 % EFFE. 116

Car No. ~~or Charge~~	Day	Act. Time Hr.	Act. Time Min.	Std. Time Hr.	Std. Time Min.	Car No. ~~or Charge~~	Day	Act. Time Hr.	Act. Time Min.	Std. Time Hr.	Std. Time Min.
92818	12/3	7		10	21	576	18-20 21	6		9	42
11133	3/4	4	30	5	48	12820	20-21	5	30	6	39
2039	4/7	5		7	48	WK'S TOTAL		132	30	168	03
WK'S TOTAL		16	30	23	57	18511	21-24	23	30	27	09
53360	9		30		30	16227	29	5	30	6	51
87842	3-4 5-6	14	30	14		17938	24-30	29		31	
92272	6.7	6	30	9	03	PLATFORM	18	1	30	1	30
5006	6	7	30	8	15	694	31	3		3	
93635.	9	1	30	2	30	250010	27-31	20	30	17	42
94947	11-13	2		4	12	98163	31	1		1	
19005	11-13 14	18	30	19	45	40087	20-22	7	30	8	51
6031	10-11 13	5		7	06	44832	2-4	10		8	
93705	11	2		2	45	TOTAL		234		273	06
6114	11-16	6	30	9	09						
616	9-10	11		9	30						
94979	16	2		2	36						
94788	16	2		2	24						
WK'S TOTAL		96		115	42						
94621	17	2		2							
94981	17	2		2	30						
9439	17	3		4	36						
125030	17-18	7		11	54						
88816	18-19	11		15							
		121		151	42						

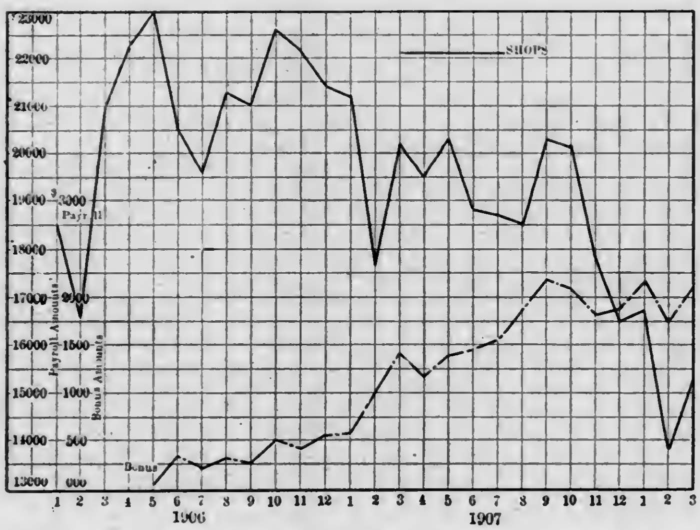
BONUS RECORD OF A CAR REPAIRMAN FOR ONE MONTH.



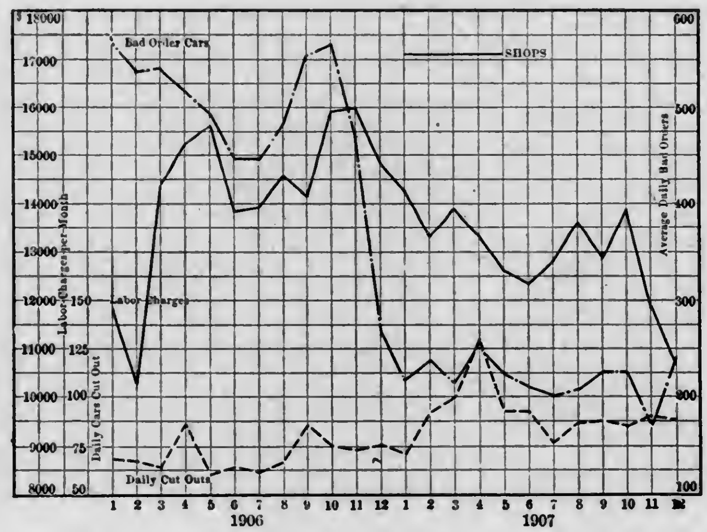
GRAPH SHOWING 12 MONTHS AVERAGES OF M. C. B. BILLS RENDERED AGAINST FOREIGN COMPANIES; 12 MONTHS AVERAGES OF AMOUNT PER 1,000 FOREIGN CAR MILES AND AVERAGES FOR 1906 AND 1907 OF AMOUNT BILLED PER 1,000 FOREIGN CAR MILES.



GRAPH SHOWING COST PER 1,000 FREIGHT CAR MILES AND NUMBER OF CARS REPAIRED PER MONTH.



GRAPH SHOWING PAYROLL (INCLUDING BONUS) AND AMOUNT PAID MONTHLY AS BONUS.



GRAPH SHOWING LABOR CHARGES PER MONTH FOR FREIGHT CAR REPAIRS; DAILY AVERAGE PER MONTH OF BAD ORDER CARS AWAITING REPAIRS AND DAILY AVERAGE PER MONTH OF BAD ORDER CARS CUT OUT FOR REPAIRS.

that if every timekeeper knows how to handle the schedule, it is being properly handled. As a safeguard against possible inaccurate handling of schedules, surprise checks are made by either visiting local points, or having the repair cards sent in and the men's methods of handling checked.

M. C. B. Rules—Classes for Studying.

Of equal importance to the correct interpretation of the schedules is the thorough understanding of the M. C. B. code of rules, the proper making of bills and the handling of interchange work. Few roads make much, if any, effort to educate their inspectors to the proper application of the M. C. B. code. They employ skilled men at good salaries at the head bill clerk's desk, but forget entirely the man who actually makes the bills. If it is so necessary that the head bill clerk be highly efficient, why is it not increasingly more important to educate the man who makes the bills? A small effort at the bottom must necessarily be felt with increased force at the top.

To bring about better results a weekly M. C. B. bill class was organized. Each Monday evening all shop foremen, bill clerks, bonus timekeepers and inspectors, and as many of the ambitious workmen as desired to attend, were instructed in the proper making of bills and interchange work. On a large blackboard a fac-simile of a standard repair card was drawn. Imperfect examples were written on the board and the members of the class were asked to correct them. Each problem was worked over until fully understood by everyone present. Verbal problems were given and the men were required to write them on the board. They were asked questions to test their knowledge of interchange work. To gauge the good accomplished, monthly written examinations were given in the class room and answers were expected to be written from memory. Each man's paper was corrected and returned to him with his grading and a correct set of answers.

All inspectors not able to attend the classes were educated and examined by letter. As the foremen, inspectors and bill clerks were required to attend these classes, those with an insufficient knowledge of the M. C. B. code were soon discovered. When a car inspector could not pass an average of 72 per cent. on three examinations he was returned to the shop. All this created a positive desire on the part of those interested to show their ability in applying the rules. Further, it naturally had a strong tendency to increase the number of correct bills rendered and to decrease the number of disputed bills.

Aid for Making Correct Repair Bills.

To still further aid those making the bills, a pamphlet was prepared showing accurately what should be shown on a bill to cover repairs made and why made. Two examples of this are as follows:

Brake Beam:

- Oak:
  - Number of beams applied.
  - Kind of material.
  - Size of material.
  - Number and size of bolts applied.
  - Solid or trussed beam.
  - Amount of paint used.
  - End of car.
  - Cause of renewal.
- Metal:
  - Number of beams applied.
  - New or second-hand.
  - State name of beam applied.
  - Renewed or repaired.
  - State whether beam is missing or broken.
  - Kind of beam removed.
  - Specify part broken.
  - End of car.
  - Cause of renewal.

Coupler:

- Number of couplers applied.
- New or second-hand.
- Kind of material in coupler applied.
- Name of coupler applied.
- Size of shank.
- Kind of attachment.
- Kind of material in coupler removed.
- Name of coupler removed.
- Specify the parts of coupler broken.
- Kind of knuckle removed and applied (open or solid).
- Condition of other parts.
- End of car.
- Cause of renewal.

The main trouble in the past has been that some important item was frequently left off the stub, or something unnecessary was added. This pamphlet instructs a man how to make out a repair card stub properly; as it has been printed and added as an appendix to the M. C. B. rule book, it can be easily followed.

That the efforts expended in such methods of education have been fully rewarded, is shown in the manner in which the foremen are now handling their work, in the interest they are taking in the successful operation of bonus, and in the improvements they are installing to increase output and work the men to the best advantage and the highest per cent. of efficiency. The foremen take as much interest in the condition of the cars as the inspectors and make it their business to see that they are repaired in the least possible time and at a minimum cost.

For some time vacancies for foremen and inspectors have been filled from members of the educational classes, and the ability of the man is thus known before appointment. Every one of the inspectors on the road has been through a rigid written examination on M. C. B. rules, in which answers can only be gotten through actual knowledge; every new inspector must have a percentage of 72 in order to qualify. This has raised the standard of the car department force much above the average and has made the men now on the road fully in favor of all the new methods and improvements instituted, since they themselves have been a part of them. This course of instruction has improved the interchange inspectors and enables them to use their judgment to better advantage than before the classes were started; the lessening of complaints is quite noticeable. Almost any improvement in the shops that has the hearty and intelligent support of the foremen is bound to succeed, and the reverse is also true. Only partial success can be expected when the foremen are indifferent. The interest taken by the foremen in the class work has been quickly reflected by the attitude of the workmen; plans for improvement that had previously been tried and met with scant success now go through without a hitch.

Number of Men to Work in a Gang.

General practice in many shops is to bunch men on a car with the idea of rushing the work, or with the desire of getting a heavy car (badly placed among a number of lights) repaired at the same time the lights are ready. Ten, twelve, and even more men are often placed on a car. The co-operation of men and foremen soon eliminated this and determined the best number. Tests were made on a number of cars requiring similar repairs. A gang of six men developed an efficiency of 86 per cent.; four men, 92 per cent.; and two men, 104 per cent. As a result of this test two men are now considered the maximum number to be worked on the body of the car and two on the trucks; as both foremen and men are affected by the increased efficiency, no trouble is found in enforcing this rule.

Delivery of Repair Material.

Another serious drawback for the workmen has been the method of securing the material. Usually each man was supposed to be his own supplyman and a large portion of his time was consumed looking for material. When he was missed by his foreman, the excuse was offered that he was hunting material. In order to overcome this, a supply gang has been organized whose duty it is to keep up a stock of all necessary small material at convenient sub-stores from which every repairman can draw what he needs. The main, or shop storehouse, is in charge of a storekeeper, who is always on duty at that point, and is required to see that the regular stock is kept up. When material is wanted by a supplyman and is not in stock, the order for such material is given the shop storekeeper and he draws from the general storehouse. Repairmen secure all their small supplies, such as bolts, nuts, nails, etc., from sub-stores, which prevents the ordering of unnecessary material as would be the case if it were delivered to them; all other material is delivered to the car by the supply gang whose leader secures the list of supplies needed and sees to the handling of all material to and from the shops during its manufacture.

Increased efficiency has resulted in increased output, decreased unit cost and decreased payrolls. With increase in efficiency and the resultant increase in bonus payments, the total payroll (bonus included) decreased, while the number of cars repaired increased. This efficiency is reflected in the decreased cost of repairs per car and car mile and in the first-class condition of the rolling stock. The accompanying diagrams show clearly the results of the introduction of the betterment methods.

PAY OF AMERICAN RAILROAD EMPLOYEES.

The report of the Interstate Commerce Commission for the year ended June 30, 1906 (full report just issued) gives the following table of the average daily pay of railroad employees for the years 1896-1906. The figures indicate dollars and cents.

Class.	United States.										
	1906.	1905.	1904.	1903.	1902.	1901.	1900.	1899.	1898.	1897.	1896.
General officers	11.81	11.74	11.61	11.27	11.17	10.97	10.45	10.03	9.73	9.54	9.19
Other officers	5.82	6.02	6.07	5.76	5.60	5.56	5.22	5.18	5.21	5.12	5.96
General office clerks	2.24	2.24	2.22	2.21	2.18	2.19	2.19	2.20	2.25	2.18	2.21
Station agents	1.94	1.93	1.93	1.87	1.80	1.77	1.75	1.74	1.73	1.73	1.73
Other station men	1.69	1.71	1.09	1.64	1.61	1.59	1.60	1.60	1.61	1.62	1.62
Enginemen	4.12	4.12	4.10	4.01	3.84	3.78	3.75	3.72	3.72	3.65	3.65
Firemen	2.42	2.38	2.35	2.28	2.20	2.16	2.14	2.10	2.09	2.05	2.06
Conductors	3.51	3.50	3.50	3.38	3.21	3.17	3.17	3.13	3.13	3.07	3.05
Other trainmen	2.35	2.31	2.27	2.17	2.04	2.00	1.96	1.94	1.95	1.90	1.90
Machinists	2.69	2.65	2.61	2.30	2.36	2.32	2.30	2.29	2.28	2.23	2.26
Carpenters	2.28	2.25	2.26	2.19	2.08	2.06	2.04	2.03	2.02	2.01	2.03
Other shopmen	1.92	1.92	1.91	1.86	1.78	1.75	1.73	1.72	1.70	1.71	1.69
Section foremen	1.80	1.79	1.78	1.78	1.72	1.71	1.68	1.68	1.69	1.70	1.70
Other trackmen	1.36	1.32	1.33	1.31	1.25	1.23	1.22	1.18	1.16	1.16	1.17
Switch tenders, crossing tenders, and watchmen.	1.80	1.79	1.77	1.76	1.77	1.74	1.80	1.77	1.74	1.72	1.74
Telegraph operators and dispatchers.	2.13	2.19	2.15	2.08	2.01	1.98	1.96	1.93	1.92	1.90	1.93
Employees—account floating equipment.	2.10	2.17	2.17	2.11	2.00	1.97	1.92	1.89	1.89	1.86	1.94
All other employees and laborers.	1.83	1.83	1.82	1.77	1.71	1.69	1.71	1.68	1.67	1.64	1.65

It will be seen that while the wages of officers, other than general officers, have decreased about 2.3% in the last ten years, the wages of enginemen have increased 13%; of firemen, 17½%; of machinists, 19%, and of the ordinary shop men, 14%.

TEST OF MALLET ARTICULATED COMPOUND LOCOMOTIVE

ERIE RAILROAD.

This test was made on one of the three locomotives delivered to the Erie Railroad by the American Locomotive Company in September, 1907, which have the distinction of being by far the largest and most powerful in the world. There were no special preparations made for the test, the locomotive being simply withdrawn from its regular service of pushing heavy trains on a very steep grade east of Susquehanna long enough to apply the apparatus and instruments for testing. During its six months' service it had received but the lightest kind of running repairs and at the time of the test it was in what might be called good condition, but not in such shape as to obtain the very best results.

The tests were made with the locomotive in its regular service, which consisted of taking its turn in pushing such trains up the grade as came along in the regular course of operation. No special trains or special loads were prepared for the purpose of testing and in each case there was a regular road locomotive at the head of the train, working to its capacity. This gave a load on the pusher engine which varied with the location of the whole train on the curves and grades and on the operation of the head engine. As a result there is no way of knowing the exact tonnage that was handled at any point of the test.

The power delivered by the locomotive was obtained by means of a dynamometer car placed between it and the train. This car, unfortunately, was not of sufficient capacity to indicate the full power of the locomotive when operated at its maximum rate, but was of sufficient capacity to give dynamometer records for a large part of the time on the test runs, the locomotive then being operated to deliver sufficient power to get the train over the hill at a speed which averaged six miles per hour.

The test as a whole, owing to the small capacity of the dynamometer car, to the small number of runs made, and to the fact that the operation of the locomotive could not be controlled by the testing crew, cannot be considered to be entirely satisfactory, nor can its absolute accuracy be vouched for. It does, however, clearly show a number of features in connection with this design of locomotive which are of greatest interest and importance. The reading of the instruments, taking the indicator cards, the weighing of the coal, etc., was done with the greatest accuracy and the lack of confidence in the results given is due to the impossibility of checking them with other runs under the same load, which allows any abnormal condition of operation, that might affect the figures to a large degree, to remain undiscovered. A number of the general results and the log of a couple of the runs are presented, which are to be understood to be simply illustrations of what the locomotive was doing at that particular time and under the conditions there prevailing.

These locomotives, as mentioned above, are the largest and most powerful ever built and were fully illustrated and described in the September, 1907, issue of this journal, page 338. They have the following general dimensions:

Service	Pushing
Fuel	Bit. Coal
Tractive effort, compound	94,800 lbs.
Weight in working order	409,000 lbs.
Weight on drivers	409,000 lbs.
Weight of engine and tender in working order	572,000 lbs.
Wheel base, rigid	14 ft. 3 in.
Wheel base, total	39 ft. 2 in.
Wheel base, engine and tender	70 ft. 5½ in.

RATIOS.

Weight on drivers ÷ tractive effort	4.32
Total weight ÷ tractive effort	4.32
Tractive effort × diam. drivers ÷ heating surface	910.00
Total heating surface ÷ grate area	53.14
Firebox heating surface ÷ total heating surface, per cent	6.46
Weight on drivers ÷ total heating surface	76.90
Volume equivalent simple cylinders, cu. ft.	24.00
Total heating surface ÷ vol. cylinders	222.00
Grate area ÷ vol. cylinders	4.17

CYLINDERS AND BOILER.

Kind	Mellin compound
Number	4
Diameter	25 and 39 in.
Stroke	28 in.
Kind, H. P. valves	Piston
Kind, L. P. valves	Richardson Bal. Slide
Greatest travel	5½ in.
Outside lap, H. P.	1⅛ in.
Outside lap, L. P.	1 in.
Inside clearance	¼ in.
Lead in full gear	3/16 in.
Driving wheels, diameter over tires	51 in.
Style of boiler	Straight, with Conical Connection
Working pressure	215 lbs.
Outside diameter of first ring	84 in.
Tubes, number and outside diameter	404—2¼ in.
Tubes, length	21 ft.
Heating surface, tubes	4,971.5 sq. ft.
Heating surface, firebox	343.2 sq. ft.
Heating surface, total	5,313.7 sq. ft.
Grate area	100 sq. ft.

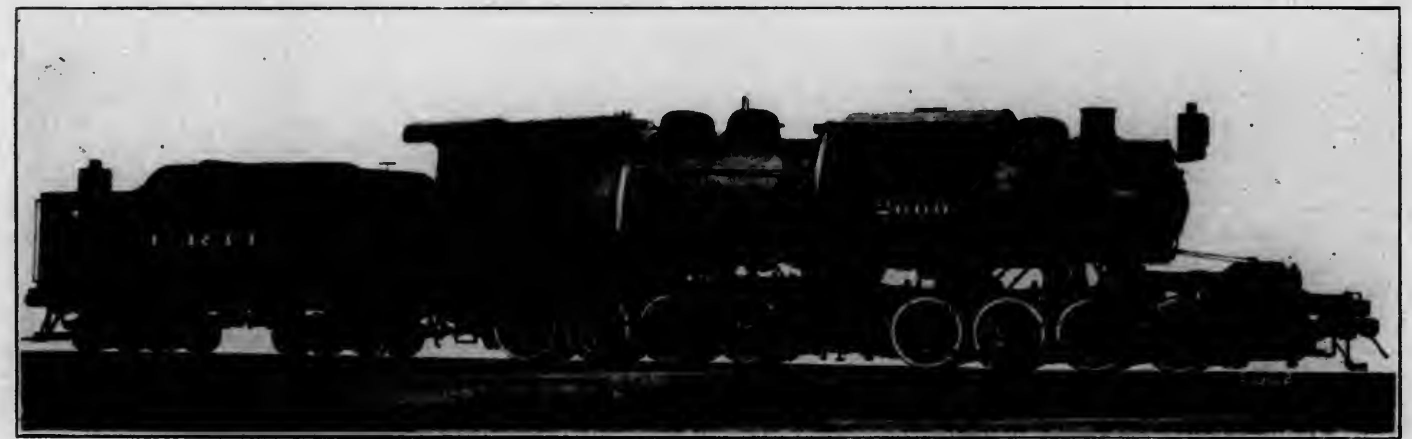


FIG. 1.—MALLET ARTICULATED COMPOUND LOCOMOTIVE OF THE TYPE TESTED ON THE ERIE RAILROAD.

METHODS OF TESTING.

Weighing the Coal.—Owing to the fact that the locomotive operated but seven miles from its terminal, pushing up the grade and then coasting back, during which time it might use to a maximum of four tons, it was possible to use a very convenient and accurate method for weighing the coal. This scheme consisted in erecting a heavy board partition across the coal space in the tank, about 3 ft. back from the coal gates, and putting the supply of coal back of this partition. Just ahead of the partition a Fairbanks scale was secured and an iron barrel, holding about 250 lbs. of coal, was placed on the platform of the scale. A sheet iron chute was arranged above this and two men standing upon the pile shoveled the coal into the barrel, which was then weighed and the coal dumped on the floor of the tender just at the coal gate, the most convenient point for the fireman. In this way it was possible to get an absolutely accurate weight of the coal used during the test.

The greatest chance for inaccuracy at this point was in the necessity of the fireman having his fire in practically the same

condition at the beginning and at the end of the run. Owing to the short time of each run and the necessity for having an exceptionally good and heavy fire at the start, this feature could exert a considerable influence on the results. In fact, the coal records for the second run have been left out of the table published herewith, on this account, as it was clearly evident that the amount of coal actually used was not in keeping with the power developed.

Measuring the Water.—The amount of water used was obtained by very carefully calibrating the tank when standing upon a track scale and getting the weight of water for each inch of depth. This depth was carefully measured at the beginning of the run, a definite point in the road, where the angle of the tender was known and correction made, and also at the end of the run where a level track was obtainable. The height of the water in the boiler was carefully brought to the same level and the waste at the injector was measured and deducted. As far as the evaporation of the water from the boiler is concerned, the results are entirely reliable. There was practically no popping off at any point, the air pump was not in operation during the run, the blower was not in use at any time during the runs given herewith, the boiler was tight at every point and all of the steam evaporated went through the cylinders except such slight amount as was used by the whistle.

Calorimeters.—The quality of the steam was taken by throttling calorimeters, the thermometer and gauges being carefully calibrated, both before and after the tests. The high pressure quality was taken from the branch pipe through an approved form of sampling pipe, at a point about 3 ft. below its connection through the boiler shell to the short dry pipe. The sample of the steam in the receiver was taken close to the joining of the U-shaped pipe just back of the low pressure cylinders, where the steam from the receiver separates to go to each of the low pressure valve chests. The connections to the calorimeters were most thoroughly and carefully lagged with about 1½ in. covering of asbestos sheets wrapped on, all being covered with a double wrapping of canvas secured with a wrapping of heavy cord. The calorimeters were turned on and left in that condition throughout the run, readings being taken at the time of taking indicator cards and other observations.

Indicators.—The connection to the indicators was made from the openings in the side of the cylinders, provided for that purpose, through ¾ in. pipes, having bends of the largest possible radius, to the three-way cock on top of which the indicator was mounted. These pipes were also very carefully lagged with asbestos and canvas. The length of pipe from the indicator to the cylinder on the high pressure cylinders was about 3 ft. and on the low pressure cylinders about 4 ft. 6 in.

The reducing motion consisted of a reducing wheel properly adjusted for the length of stroke, so as to give approximately a 3½ in. card. These were so arranged and connected to the indicator as to allow the disconnecting of the cord between the reducing wheel and the indicator drum to allow the application of the indicator cards. The cord from the reducing wheel was led to a light but stiff bracket projecting out and upward from the cross head.

This arrangement of reducing motion was very satisfactory on the whole, but gave very serious trouble when the engine would slip for several revolutions, at which time the cords would be snapped. This made it necessary to delay the starting of the test until the engine was well under way when the possibility of slipping, greatest at starting, had been largely eliminated.

Vacuum Gauge.—The vacuum in the front end was obtained by the reading of a water manometer, which was connected by a short section of rubber tubing to a ¾ in. pipe projecting two-thirds the distance across the front end at a point about 1 ft. ahead of the diaphragm apron and about 6 in. above its bottom edge. This pipe was open at the end and contained a spiral series of ⅛ in. holes spaced about 3 in. apart for two-thirds of its length.

Flue Gas Analysis.—The sample of flue gas was taken through a ¾ in. pipe, located about 6 in. ahead of the vacuum gauge pipe, which was plugged at the end and had a series of ¼ in. holes, 3 in. apart, drilled in a straight line for its entire length. This pipe extended across the center two-thirds of the width of the front end at this point and was continued by an elbow through the front end ring to the sampling connection. The samples were very carefully taken, there being at least one full bottle wasted before the sample was taken. The analysis was made in an Orsat apparatus located in the dynamometer car. Samples were taken as rapidly as they could be analyzed. The analysis was made for CO_2, CO and O, the N being obtained by difference. The average figure for the series of each run is given in the table. The apparatus was not in working order for the first run.

Revolution Counters.—A revolution counter was attached to each set of engines, being located at a convenient point on the running board and having its cord connected to the valve gear link. These counters were read at intervals of one minute throughout the run.

Other Apparatus.—The pressures in the branch pipe and receiver pipes were taken from the gauges on the calorimeters, a valve being arranged so as to shut off the calorimeter temporarily from the gauge and give an accurate reading of the pressure. These gauges, as well as all other steam gauges, thermometers and indicator springs were carefully calibrated after the test. The coal sample was taken by shoveling 50 lbs. of coal, consisting of both lumps and fine, into a bucket; this was then dumped on to a platform, carefully crushed into fine bits, thoroughly mixed and a 1 lb. sample taken and sealed in a glass jar. The analyses were made at Cornell University, the figures given being an average.

The temperature of the feed water was taken at the beginning and end of each run and the temperature of the exhaust steam was taken at intervals of three minutes, a thermometer cup being inserted in the pipe connecting the exhaust passage with the nozzle.

The diameter of the wheels was carefully calipered at a number of points in the circumference of each and were found to vary but slightly on each set of engines. The figure used is an average of all of the observations on the wheels of each engine.

The boiler steam pressure, length of time of injector in action, and position of throttle and reverse lever were noted by the observer in the cab, who also gave the signal for the taking of cards and other observations.

Owing to the short time available for fitting up the locomotive it was necessary to give the signal for taking cards by means of a short blast of the locomotive whistle.

Dynamometer Car.—The dynamometer car used was owned by the Erie Railroad and was of the spring type. It had a maximum capacity of 70,000 lbs. and was of comparatively light construction. The underframe consisted of wooden longitudinal sills, to which the stops for the springs were fastened. The recording pen was connected directly to the spring by levers extending up through the floor. The paper was driven through a connection to the axle of one of the truck wheels which was arranged to drive the paper at a speed corresponding to 1 ft. per mile. As a check on this the time of passing mile posts was carefully noted on the record and the actual speed of operation was taken from these records by means of the 15 second notches obtained by electrical connection to a chronometer. The time of taking indicator cards and other observations was noted by an electrical pen movement on the paper.

It is felt that, owing to the entirely too light construction of the car for service ahead of a locomotive of this capacity, which at many times in starting, before the test was begun, compelled the disconnecting of the indicating apparatus from the spring to prevent it being destroyed and the spring at these times coming up solid and the remainder of the stress being taken by the connection of the springs to the wooden sills, the dynamometer records may be open to some question in that they may be slightly too high. The constant error would be due to any lost motion that there might be between the spring stops and the sills. Such an error if it exists has not been corrected for and in any case would probably not exceed 2,000 or 3,000 lbs.

The dynamometer car was in charge of Mr. R. B. Watson, engineer of tests of the Erie Railroad.

TEST OF MALLET ARTICULATED COMPOUND LOCOMOTIVE

ERIE RAILROAD.

This test was made on one of the three locomotives delivered to the Erie Railroad by the American Locomotive Company in September, 1907, which have the distinction of being by far the largest and most powerful in the world. There were no special preparations made for the test, the locomotive being simply withdrawn from its regular service of pushing heavy trains on a very steep grade east of Susquehanna long enough to apply the apparatus and instruments for testing. During its six months' service it had received but the lightest kind of running repairs and at the time of the test it was in what might be called good condition, but not in such shape as to obtain the very best results.

The tests were made with the locomotive in its regular service, which consisted of taking its turn in pushing such trains up the grade as came along in the regular course of operation. No special trains or special loads were prepared for the purpose of testing and in each case there was a regular road locomotive at the head of the train, working to its capacity. This gave a load on the pusher engine which varied with the location of

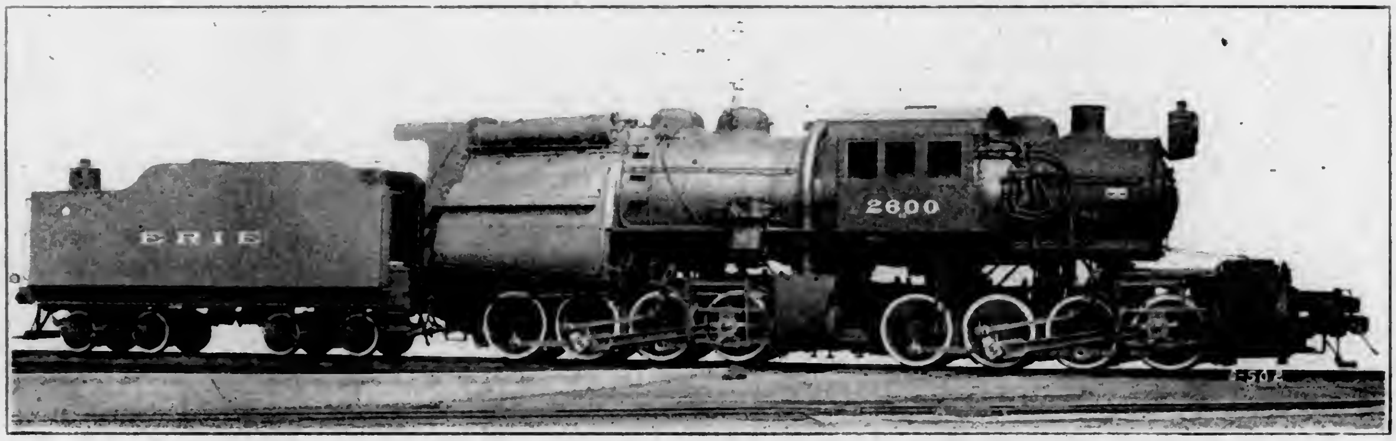


FIG. 1.—MALLET ARTICULATED COMPOUND LOCOMOTIVE OF THE TYPE TESTED ON THE ERIE RAILROAD.

the whole train on the curves and grades and on the operation of the head engine. As a result there is no way of knowing the exact tonnage that was handled at any point of the test.

The power delivered by the locomotive was obtained by means of a dynamometer car placed between it and the train. This car, unfortunately, was not of sufficient capacity to indicate the full power of the locomotive when operated at its maximum rate, but was of sufficient capacity to give dynamometer records for a large part of the time on the test runs, the locomotive then being operated to deliver sufficient power to get the train over the hill at a speed which averaged six miles per hour.

The test as a whole, owing to the small capacity of the dynamometer car, to the small number of runs made, and to the fact that the operation of the locomotive could not be controlled by the testing crew, cannot be considered to be entirely satisfactory, nor can its absolute accuracy be vouched for. It does, however, clearly show a number of features in connection with this design of locomotive which are of greatest interest and importance. The reading of the instruments, taking the indicator cards, the weighing of the coal, etc., was done with the greatest accuracy and the lack of confidence in the results given is due to the impossibility of checking them with other runs under the same load, which allows any abnormal condition of operation, that might affect the figures to a large degree, to remain undiscovered. A number of the general results and the log of a couple of the runs are presented, which are to be understood to be simply illustrations of what the locomotive was doing at that particular time and under the conditions there prevailing.

These locomotives, as mentioned above, are the largest and most powerful ever built and were fully illustrated and described in the September, 1907, issue of this journal, page 338. They have the following general dimensions:

Service	Pushing
Fuel	Bit. Coal
Tractive effort, compound	94,800 lbs.
Weight in working order	409,000 lbs.
Weight on drivers	409,000 lbs.
Weight of engine and tender in working order	572,000 lbs.
Wheel base, rigid	14 ft. 3 in.
Wheel base, total	39 ft. 2 in.
Wheel base, engine and tender	70 ft. 5½ in.

RATIOS.

Weight on drivers ÷ tractive effort	4.32
Total weight ÷ tractive effort	4.32
Tractive effort × diam. drivers ÷ heating surface	910.00
Total heating surface ÷ grate area	53.14
Firebox heating surface ÷ total heating surface, per cent	6.46
Weight on drivers ÷ total heating surface	76.90
Volume equivalent simple cylinders, cu. ft.	24.00
Total heating surface ÷ vol. cylinders	222.00
Grate area ÷ vol. cylinders	4.17

CYLINDERS AND BOILER.

Kind	Mellin compound
Number	4
Diameter	25 and 39 in.
Stroke	28 in.
Kind, H. P. valves	Piston
Kind, L. P. valves	Richardson Bal. Slide
Greatest travel	5½ in.
Outside lap, H. P.	1⅛ in.
Outside lap, L. P.	1 in.
Inside clearance	¼ in.
Lead in full gear	3/16 in.
Driving wheels, diameter over tires	51 in.
Style of boiler	Straight, with Conical Connection
Working pressure	215 lbs.
Outside diameter of first ring	84 in.
Tubes, number and outside diameter	404—2¼ in.
Tubes, length	21 ft.
Heating surface, tubes	4,971.5 sq. ft.
Heating surface, firebox	343.2 sq. ft.
Heating surface, total	5,313.7 sq. ft.
Grate area	100 sq. ft.

Methods of Testing.

Weighing the Coal.—Owing to the fact that the locomotive operated but seven miles from its terminal, pushing up the grade and then coasting back, during which time it might use to a maximum of four tons, it was possible to use a very convenient and accurate method for weighing the coal. This scheme consisted in erecting a heavy board partition across the coal space in the tank, about 3 ft. back from the coal gates, and putting the supply of coal back of this partition. Just ahead of the partition a Fairbanks scale was secured and an iron barrel, holding about 250 lbs. of coal, was placed on the platform of the scale. A sheet iron chute was arranged above this and two men standing upon the pile shoveled the coal into the barrel, which was then weighed and the coal dumped on the floor of the tender just at the coal gate, the most convenient point for the fireman. In this way it was possible to get an absolutely accurate weight of the coal used during the test.

The greatest chance for inaccuracy at this point was in the necessity of the fireman having his fire in practically the same

condition at the beginning and at the end of the run. Owing to the short time of each run and the necessity for having an exceptionally good and heavy fire at the start, this feature could exert a considerable influence on the results. In fact, the coal records for the second run have been left out of the table published herewith, on this account, as it was clearly evident that the amount of coal actually used was not in keeping with the power developed.

Measuring the Water.—The amount of water used was obtained by very carefully calibrating the tank when standing upon a track scale and getting the weight of water for each inch of depth. This depth was carefully measured at the beginning of the run, a definite point in the road, where the angle of the tender was known and correction made, and also at the end of the run where a level track was obtainable. The height of the water in the boiler was carefully brought to the same level and the waste at the injector was measured and deducted. As far as the evaporation of the water from the boiler is concerned, the results are entirely reliable. There was practically no popping off at any point, the air pump was not in operation during the run, the blower was not in use at any time during the runs given herewith, the boiler was tight at every point and all of the steam evaporated went through the cylinders except such slight amount as was used by the whistle.

Calorimeters.—The quality of the steam was taken by throttling calorimeters, the thermometer and gauges being carefully calibrated, both before and after the tests. The high pressure quality was taken from the branch pipe through an approved form of sampling pipe, at a point about 3 ft. below its connection through the boiler shell to the short dry pipe. The sample of the steam in the receiver was taken close to the joining of the U-shaped pipe just back of the low pressure cylinders, where the steam from the receiver separates to go to each of the low pressure valve chests. The connections to the calorimeters were most thoroughly and carefully lagged with about 1½ in. covering of asbestos sheets wrapped on, all being covered with a double wrapping of canvas secured with a wrapping of heavy cord. The calorimeters were turned on and left in that condition throughout the run, readings being taken at the time of taking indicator cards and other observations.

Indicators.—The connection to the indicators was made from the openings in the side of the cylinders, provided for that purpose, through ¾ in. pipes, having bends of the largest possible radius, to the three-way cock on top of which the indicator was mounted. These pipes were also very carefully lagged with asbestos and canvas. The length of pipe from the indicator to the cylinder on the high pressure cylinders was about 3 ft. and on the low pressure cylinders about 4 ft. 6 in.

The reducing motion consisted of a reducing wheel properly adjusted for the length of stroke, so as to give approximately a 3½ in. card. These were so arranged and connected to the indicator as to allow the disconnecting of the cord between the reducing wheel and the indicator drum to allow the application of the indicator cards. The cord from the reducing wheel was led to a light but stiff bracket projecting out and upward from the cross head.

This arrangement of reducing motion was very satisfactory on the whole, but gave very serious trouble when the engine would slip for several revolutions, at which time the cords would be snapped. This made it necessary to delay the starting of the test until the engine was well under way when the possibility of slipping, greatest at starting, had been largely eliminated.

Vacuum Gauge.—The vacuum in the front end was obtained by the reading of a water manometer, which was connected by a short section of rubber tubing to a ¾ in. pipe projecting two-thirds the distance across the front end at a point about 1 ft. ahead of the diaphragm apron and about 6 in. above its bottom edge. This pipe was open at the end and contained a spiral series of ⅛ in. holes spaced about 3 in. apart for two-thirds of its length.

Flue Gas Analysis.—The sample of flue gas was taken through a ¾ in. pipe, located about 6 in. ahead of the vacuum gauge pipe, which was plugged at the end and had a series of ¼ in. holes, 3 in. apart, drilled in a straight line for its entire length. This pipe extended across the center two-thirds of the width of the front end at this point and was continued by an elbow through the front end ring to the sampling connection. The samples were very carefully taken, there being at least one full bottle wasted before the sample was taken. The analysis was made in an Orsat apparatus located in the dynamometer car. Samples were taken as rapidly as they could be analyzed. The analysis was made for CO_2, CO and O, the N being obtained by difference. The average figure for the series of each run is given in the table. The apparatus was not in working order for the first run.

Revolution Counters.—A revolution counter was attached to each set of engines, being located at a convenient point on the running board and having its cord connected to the valve gear link. These counters were read at intervals of one minute throughout the run.

Other Apparatus.—The pressures in the branch pipe and receiver pipes were taken from the gauges on the calorimeters, a valve being arranged so as to shut off the calorimeter temporarily from the gauge and give an accurate reading of the pressure. These gauges, as well as all other steam gauges, thermometers and indicator springs were carefully calibrated after the test. The coal sample was taken by shoveling 50 lbs. of coal, consisting of both lumps and fine, into a bucket; this was then dumped on to a platform, carefully crushed into fine bits, thoroughly mixed and a 1 lb. sample taken and sealed in a glass jar. The analyses were made at Cornell University, the figures given being an average.

The temperature of the feed water was taken at the beginning and end of each run and the temperature of the exhaust steam was taken at intervals of three minutes, a thermometer cup being inserted in the pipe connecting the exhaust passage with the nozzle.

The diameter of the wheels was carefully calipered at a number of points in the circumference of each and were found to vary but slightly on each set of engines. The figure used is an average of all of the observations on the wheels of each engine.

The boiler steam pressure, length of time of injector in action, and position of throttle and reverse lever were noted by the observer in the cab, who also gave the signal for the taking of cards and other observations.

Owing to the short time available for fitting up the locomotive it was necessary to give the signal for taking cards by means of a short blast of the locomotive whistle.

Dynamometer Car.—The dynamometer car used was owned by the Erie Railroad and was of the spring type. It had a maximum capacity of 70,000 lbs. and was of comparatively light construction. The underframe consisted of wooden longitudinal sills, to which the stops for the springs were fastened. The recording pen was connected directly to the spring by levers extending up through the floor. The paper was driven through a connection to the axle of one of the truck wheels which was arranged to drive the paper at a speed corresponding to 1 ft. per mile. As a check on this the time of passing mile posts was carefully noted on the record and the actual speed of operation was taken from these records by means of the 15 second notches obtained by electrical connection to a chronometer. The time of taking indicator cards and other observations was noted by an electrical pen movement on the paper.

It is felt that, owing to the entirely too light construction of the car for service ahead of a locomotive of this capacity, which at many times in starting, before the test was begun, compelled the disconnecting of the indicating apparatus from the spring to prevent it being destroyed and the spring at these times coming up solid and the remainder of the stress being taken by the connection of the springs to the wooden sills, the dynamometer records may be open to some question in that they may be slightly too high. The constant error would be due to any lost motion that there might be between the spring stops and the sills. Such an error if it exists has not been corrected for and in any case would probably not exceed 2,000 or 3,000 lbs.

The dynamometer car was in charge of Mr. R. B. Watson, engineer of tests of the Erie Railroad.

Run Number	Time in Minutes.	Front Engine.							Back Engine.							Pressure, pounds per sq. inch.					Draft in Front End.	Injector in Action. Minutes.	Pounds Water.			Dynamometer.		
		R. P. M.			M. P. H. Average.	Piston Speed ft. per min.			R. P. M.			M. P. H. Average.	Piston Speed, feet per Minute.			In Boiler.			In Branch Pipe.	In Receiver.			Delivered.	Loss.	Evaporated.	Pounds, Maximum.	Pounds, Minimum.	Pounds, Average.
		Max.	Min.	Ave.		Max.	Min.	Ave.	Max.	Min.	Ave.		Max.	Min.	Ave.	Max.	Min.	Ave.										
1	60	52	30	40	6.	244	141	187	47	30	40	6.	220	141	187	210	198	200	185	......	4.7	53	43,410	505	42,905	69,500	59,000	64,000
2	63	56	17	43	6.	234	79	187	51	14	40	6.	240	66	187	210	155	200	171	50	5.0	58	40,270	552	39,718	......	59,000	66,000
3	113	47	14	33	5.	220	66	154	50	14	33	5.	234	66	154	210	165	195	176	56	4.5	99	48,920	942	47,978	70,000	58,000	64,000

Run Number.	Boiler.		I. H. P.				Division of Power.				Consumed Per I. H. P. Hour.			Locomotive.												
																Per D. H. P.			I. H. P. Per sq. ft.		D. H. P. Per sq. ft.		Machine Friction.			
	Horse Power.	Efficiency.	Right High Pressure.	Left High Pressure.	Right Low Pressure.	Left Low Pressure.	High Pressure.	Low Pressure.	Right Side.	Left Side.	Dry Coal.	Dry Steam.	B. T. U.	Total I. H. P.	Total D. H. P.	Dry Coal.	Dry Steam.	B. T. U.	H. S.	G. A.	H. S.	G. A.	H. P.	Darwbar Pull.	Machine Efficiency.	Efficiency.
1	1.520	80.5	317	309	248	267	626	515	565	576	4.3	37.2	54,000	1,141	1,021	4.8	41.6	60,000	.215	11.41	.192	10.21	120	7,500	89	4.24
2	1,330	....	257	251	251	253	508	504	508	504	....	36.9	....	1,012	889	......	42.4	....	.191	10.12	.166	8.89	123	7,700	88	......
3	900	61.	218	216	224	228	434	452	442	444	4.2	29.0	52,500	886	710	5.6	35.4	65,700	.166	8.86	.133	7.10	176	13,200	80	3.88

TABLE OF GENERAL RESULTS OF THREE RUNS. TEST OF MALLET ARTICULATED LOCOMOTIVE—ERIE RAILROAD.

Pyrometer.—A pyrometer, operating a hand on a dial by means of the expansion of an enclosed gas, was inserted in the front end at a location about the center of the flues and half-way between the flue sheet and the diaphragm. Owing, however, to the impossibility of calibrating this instrument for the temperatures at which it was used, and its gross inaccuracy at such temperatures as were available for calibration, made it seem advisable to eliminate the records obtained from it.

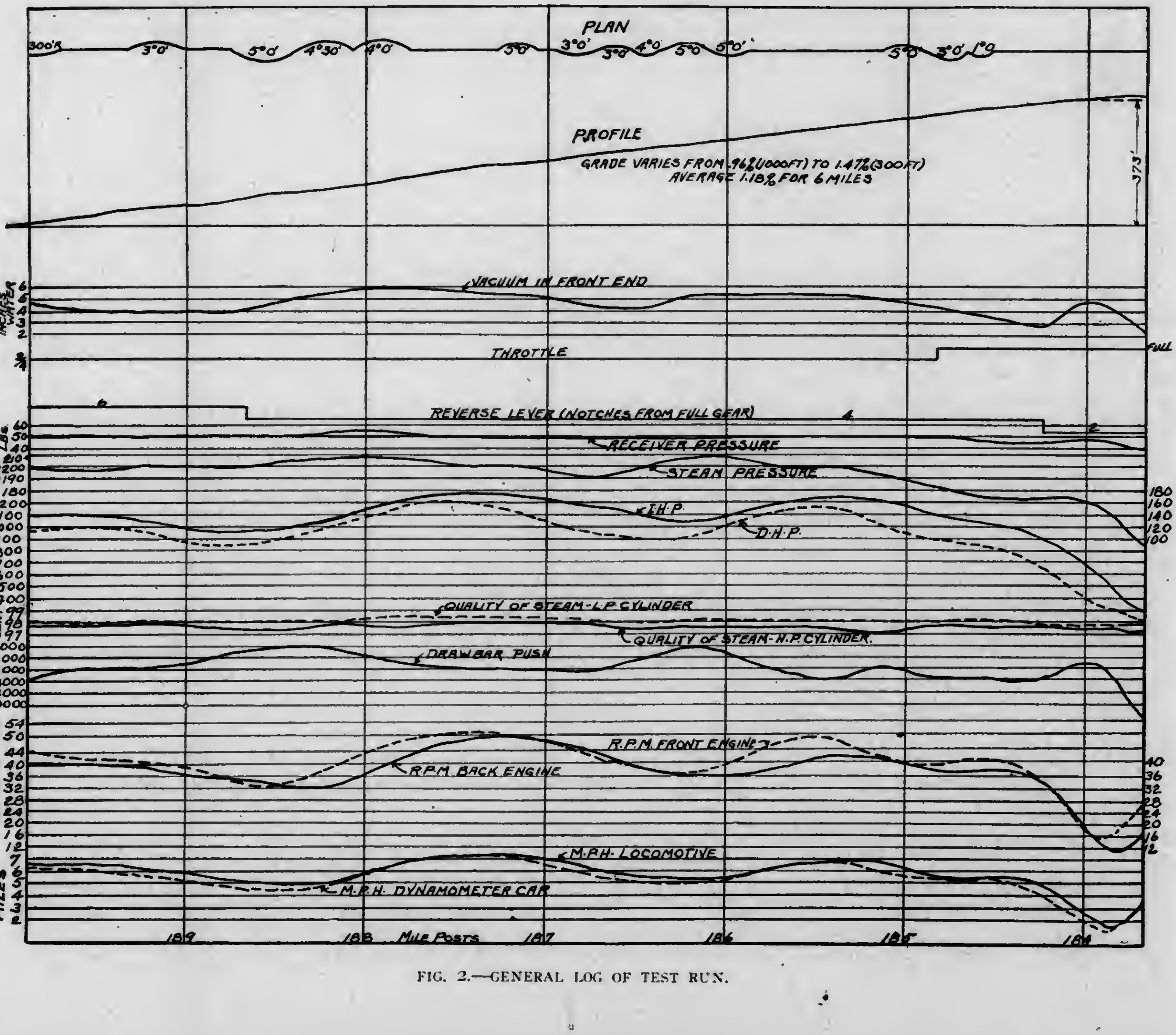


FIG. 2.—GENERAL LOG OF TEST RUN.

Run Number.	Coal. Fired. Kind.	Coal. Fired. Total, Pounds.	Coal. Fired. Moisture per cent.	Coal. Total, Pounds. Dry Coal.	Coal. Total, Pounds. Combustible.	Coal. Total, Pounds. Ash, by Analysis.	Coal. Analysis of Coal. Fixed C.	Coal. Analysis of Coal. Volatile Matter.	Coal. Analysis of Coal. Ash.	Coal. Value in B. T. U. Moist Coal.	Coal. Value in B. T. U. Combustible.	Coal. Dry Coal Fired. Per Hour.	Coal. Dry Coal Fired. Per square ft. G. A.	Flue Gas. Per Cent. O.	Flue Gas. Per Cent. CO.	Flue Gas. Per Cent. CO_2.	Flue Gas. Per Cent. N.	Quality of Steam. Branch Pipe.	Quality of Steam. Receiver.	Evaporation in Pounds. Steam per Hour. Moist.	Evaporation in Pounds. Steam per Hour. Dry.	Evaporation in Pounds. Steam per Hour. Dry per sq. ft. H. S.	Evaporation in Pounds. Dry Steam per Pound Dry Coal.	Equivalent Evaporation from and at 212°. Per Hour, Pounds.	Equivalent Evaporation from and at 212°. Per square ft. H. S. Per Hour.	Equivalent Evaporation from and at 212°. Per Pound Coal. As Fired.	Equivalent Evaporation from and at 212°. Per Pound Coal. Dry.	Equivalent Evaporation from and at 212°. Per Pound Coal. Combustible.
1	Bit.	5,065	3.1	4,910	4,125	785	52.8	28.4	15.7	12,100	14,910	4,910	49.1	......	......	......	......	99.08	....	42,905	42.500	7.96	8.66	52,300	9.85	10.46	10.70	12.7
2	"	....	3.1	......	......	......	52.8	28.4	15.7	12,100	14,910	....	......	4.08	.36	12.68	82.67	97.65	98.05	37,900	37,065	6.95	....	45,800	8.62	......	......	......
	"	7,218	3.1	7,000	5,900	1,100	52.8	28.4	15.7	12,100	14,910	3,980	39.8	8.86	1.12	9.68	80.34	98.39	98.14	25.460	25,060	4.70	6.32	31,000	5.92	7.80	8.08	9.6

RESULT OF TESTS.

The log of two of the best runs, shown in Figs. 2 and 3, are self-explanatory. It will be noticed that there is a variation in the r. p. m. between the front and the rear engine, all of which is not accounted for by the difference in the diameter of the drivers. This, of course, is due to one of the engines slipping when the other did not. This, as will be seen from the curves, usually occurred with the front engine and was probably due to variation in the track, reducing the weight on this set of wheels for short periods. The actual slipping of the engine during the two runs illustrated was not sufficient to be noticeable and seldom exceeded a half of a revolution. There, of course, might have been, and probably was, a slight amount of slipping at various times which was not sufficient to attract attention.

The mile per hour curves of the locomotive and dynamometer car vary from the same causes. The speed of the locomotive was taken from the revolutions multiplied by the circumference of the drivers, the lower r. p. m. readings being used in each case, while the speed of the dynamometer car is taken from the record, as above explained. The indicated h.p. and dynamometer h.p. curves vary in exactly the same manner as do the speed curves and for the same reason. The plan and profile of the road, given at the top of each log, should be considered in inspecting these curves.

The table of general results presents some very interesting figures, which, however, as explained, are in some instances open to question. The first run will be seen to have been the best as far as economy is concerned and clearly illustrates the capacity of one of these machines when being fired by one fireman, who was not by any means seriously overworked. In connection with the amount of steam used per indicated h.p., which looks to be very large for a compound locomotive, it might be mentioned that at the time of these runs there was a considerable leakage of steam at the cylinders and that these wastes have not been deducted. This, of course, only affects the engine performance and does not enter into the boiler results. The quality of steam is noticeable, particularly that in the receiver, where over 98 per cent. steam was obtained practically all the time. This was a feature of the Mallet compound locomotive concerning which there had been some doubt, and the results show that in spite of the long and exposed receiver pipe the low pressure cylinders are getting nearly as dry steam as the high pressure and in the second run were even getting better on the average. This is probably due to the large volume

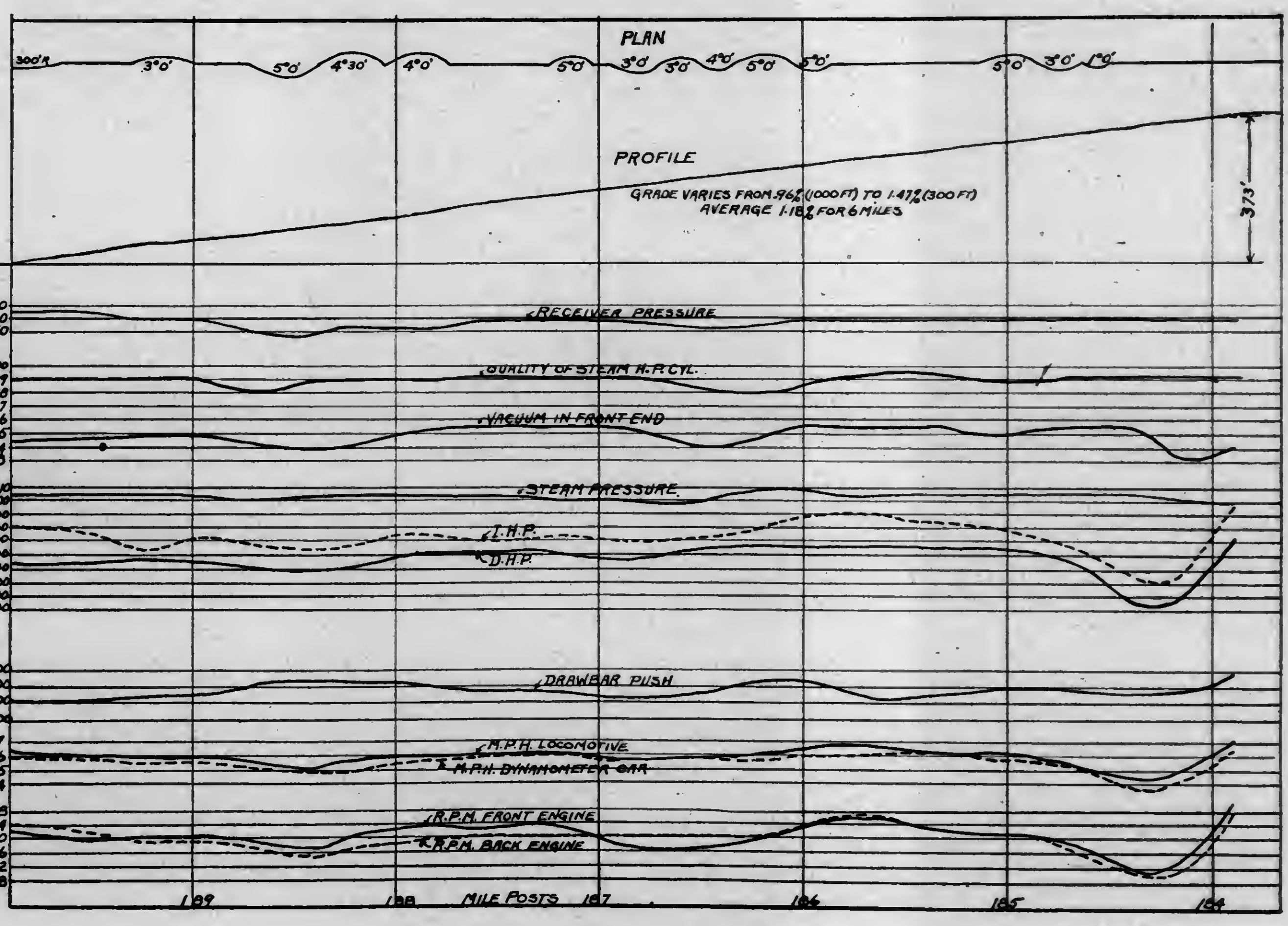
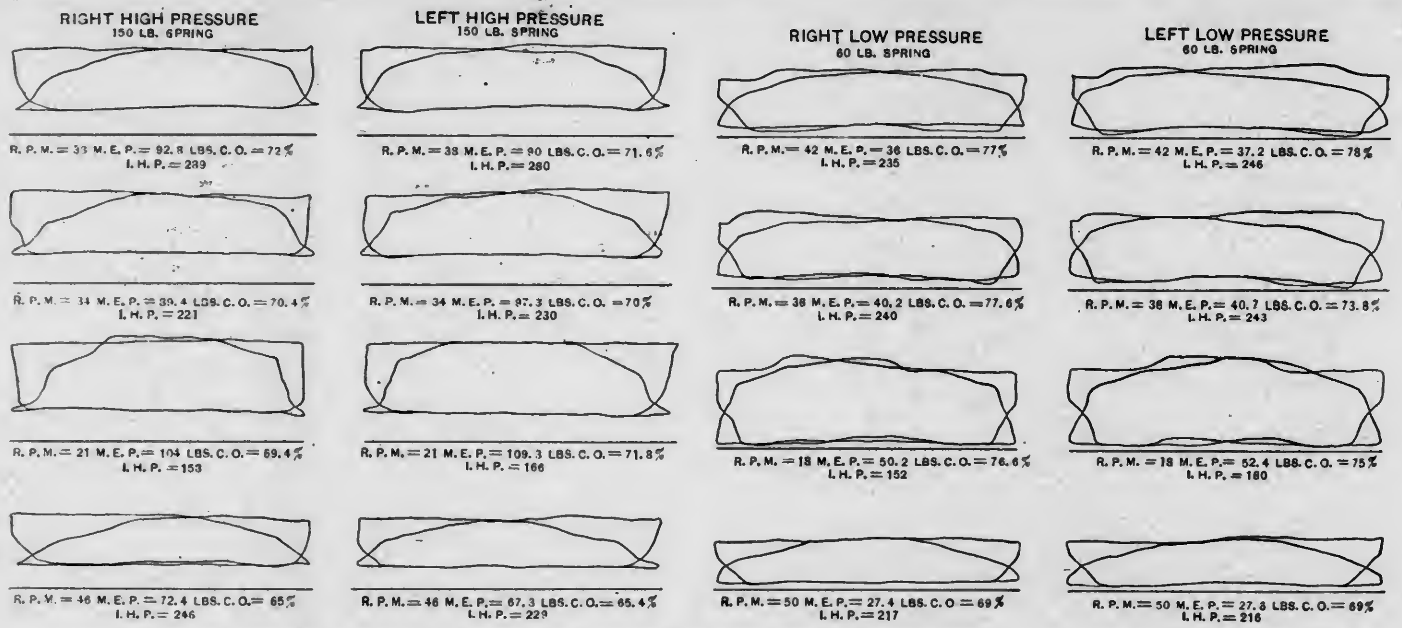


FIG. 3.—GENERAL LOG OF TEST RUN.



Top row illustrates the effect of a high pressure exhaust at about ⅛ stroke of low pressure cylinder. Second row illustrates the effect of a high pressure exhaust at beginning of low pressure stroke. Third row illustrates the effect of admission of high pressure steam to low pressure cylinder. Fourth row illustrates working at higher speed with very low boiler pressure and earlier cut off.

FIG. 4.—TYPICAL INDICATOR CARDS.

of the receiver pipe, which allows some wire drawing and consequently superheating of the steam in entering it from the high pressure valve chamber.

The poor results shown on the third run, as compared with the first and second, are explained by the fact that fireman was not of a grade equal to the men who fired the first two runs and did not maintain his fire in as good condition, or keep the steam pressure anywhere near as constant as did the other men.

In Fig. 4 are shown a number of typical indicator cards, the characteristics of which are noted in the caption under the cut. These cards indicate very clearly the effect of the exhaust of the high pressure cylinders on the pressure in the low pressure cylinders. This exhaust, of course, may come at any point in the stroke and actually does vary constantly. The ideal condition in this respect would be an exhaust coming just at the opening of the admission, about as shown in the second row of cards, or just following the point of cut-off, which is shown in one of the cards of the fourth row. In both cases the low pressure cylinders get the full benefit of this high pressure in the receiver at the beginning of the stroke. The cards, as a whole, present a number of points of interest, which are clearly evident in the illustration. It will be seen how the exhaust from one low pressure cylinder creates a considerable increase in the back pressure of the other cylinder, and also how the opening of the admission or the cut-off of the low pressure cylinders seems to have no appreciable effect upon the exhaust line of the high pressure.

In Figs. 5 and 6 are given some sample dynamometer car records, which will be seen to have some extremely unusual characteristics. A draw bar pull, particularly with a spring dynamometer car, which presents very nearly a straight line for a time of three minutes covering a distance of 2,000 ft., such as is shown in Fig. 5, would be practically impossible with any type of locomotive except a Mallet compound. Such a condition is, of course, due to the two sets of engines assuming a relation so that the cranks are an eighth of a revolution apart, thus together maintaining a constant and steady push, or pull. It will be noticed that just at the end of this section of straight line there is considerable variation in the draw bar push, which is undoubtedly due to one set of drivers slipping slightly and getting in step with the other. In examining these dynamometer car

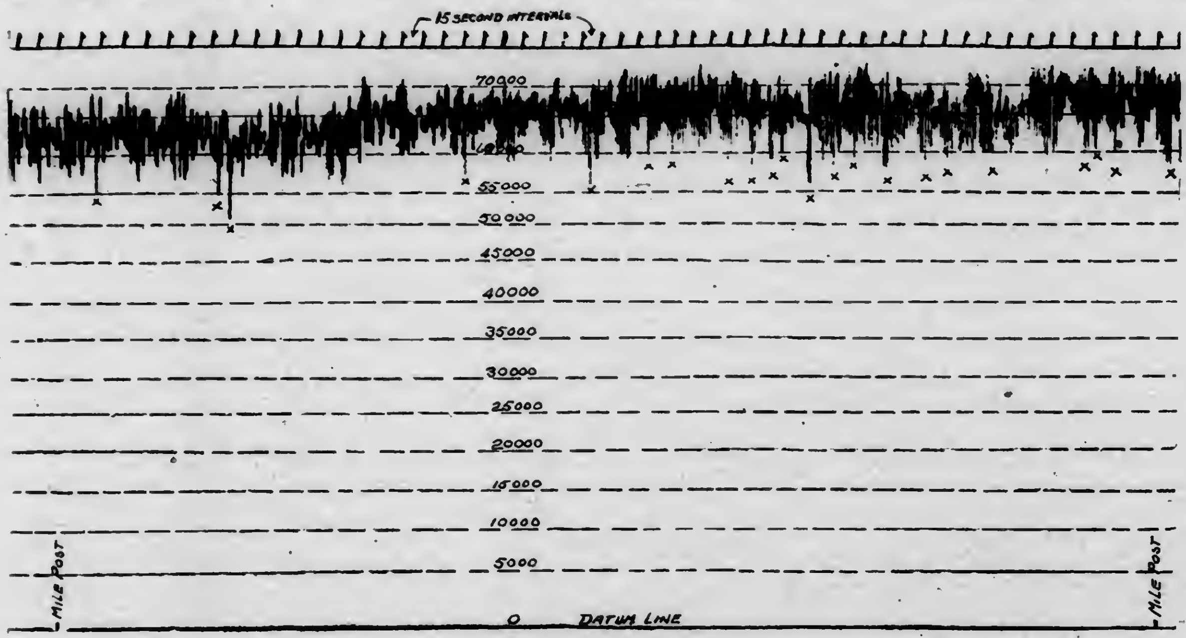


FIG. 6.—SECTION OF DYNAMOMETER RECORD SHOWING EFFECT OF SLIPPING.

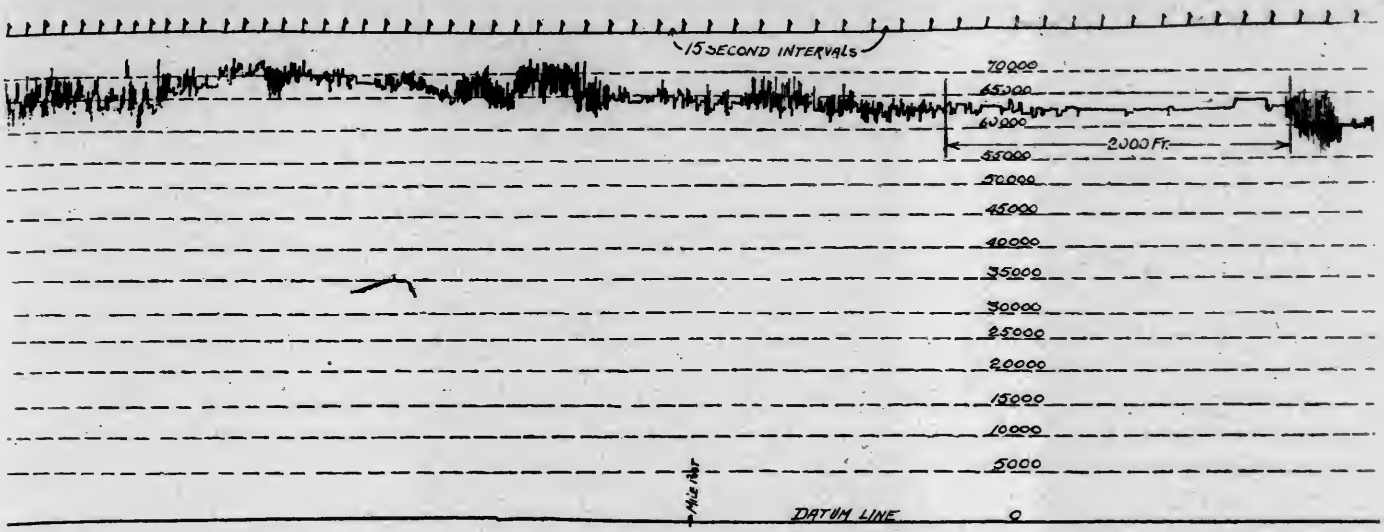


FIG. 5.—SAMPLE DYNAMOMETER RECORD SHOWING THE CONSTANT, STEADY TRACTIVE EFFORT.

records it should be remembered that there was a locomotive on the head end of the train and that any slipping or uneven operation of it would be conducted back through the train to the dynamometer car and set up a series of surges which would show on the record, although they might not be due to the pusher engine.

The record shown in Fig. 6 was a part of the run where there was a very poor rail, which, in connection with a shortage of sand, made the locomotive slip a great deal. It might be mentioned that this record is taken from a run which is not shown in the table of data. The points marked X in the illustration are the points of slippage and it can be seen that the draw bar push was reduced but very little by the slipping of the engine. This effect is obtained because of the fact that one set of drivers slipped at a time and that this slippage would seldom cover a whole revolution. For instance, when the low pressure engine would slip it would soon exhaust its supply of steam and necessarily stop. This would reduce the back pressure on the high pressure engine and it would exert a greater pull to counteract the loss on the low pressure. The reverse is also true because when the high pressure engine slips it rapidly builds up the back pressure in the receiver, thus decreasing its own power and increasing that on the low pressure. The dynamometer car record shows the net result very clearly. Both of these records show how closely to the capacity of the dynamometer the records were taken.

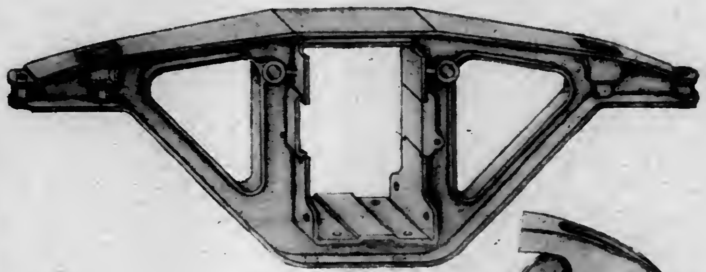
The arrangements for these tests were made and the apparatus was provided by Messrs. C. R. Cullen and S. D. Gridley, seniors at Cornell University, who are using the results as a basis for a thesis to be presented for graduation. The observers on the test were members of the junior and senior classes at Cornell and special apprentices on the Erie Railroad.

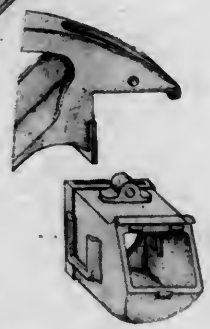
DEVELOPMENT OF CAR TRUCK SIDE FRAME CONSTRUCTION.

An interesting modification has been embodied in the design of a freight car truck frame, consisting of a separable cast steel journal box interlocking with a cast steel frame, thus dispensing with all column and journal box bolts in a strong and practical manner; a single bolt is applied as a key at each box to maintain the boxes in place in case of derailment. If desired, journal box bolt holes may be provided permitting the application of a standard M. C. B. box in combination with a tie bar, thus facilitating repairs in the event of an accident to the box on a foreign road. These frames are also made in a design to take the standard M. C. B. boxes only.

An important feature of both truck designs is the simple method by which the truck bolster is applied. An enlarged opening is provided near the center section of the column guides, of sufficient width to admit the flanged guides of the bolster. The bolster after being placed in position is either raised or lowered and the column guide opening closed with an interlocking filler securely locked against removal when the bolster is in its normal position.

CAST STEEL FREIGHT CAR TRUCK SIDE FRAME.





CAST STEEL FREIGHT CAR TRUCK SIDE FRAME AND A MODIFICATION PERMITTING THE USE OF AN INTERLOCKING CAST STEEL JOURNAL BOX AND DISPENSING WITH JOURNAL BOX BOLTS.

These filler-blocks are in no sense keys. When in place they become integral parts of the column and have no tendency to wear loose in service. Besides providing a renewable chafing plate this filler construction permits the application or removal of the truck bolster without the necessity of dismantling the truck. The truck is designed either with the spring seat cast integral or made to receive a separate cast steel or malleable spring seat. It is adapted to any form of spring plank or truck tie bar, or may be furnished with an interlocking cast steel spring plank.

The side frame is made of basic steel melted with natural gas. Basic steel made in this manner is uniformly low in sulphur and phosphorus; this is an important consideration in steel for truck side frames, which are subject to direct vibratory shocks. This truck side frame is manufactured by the Pittsburgh Equipment Company, House Building, Pittsburgh.

THE SOLUTION OF THE CRANK AXLE PROBLEM

By Howard H. Lanning.*

American locomotives are of the simplest design, with large factors of safety in the proportions of their parts. As a consequence they can be built cheaply and quickly, and can be repaired by the crudest means. In Europe it has been customary to give much more thought and attention to these matters, and the claim is made that it takes three years to build a locomotive over there; one year to thoroughly work out the design in all its details; a second year to build one or two of the type and thoroughly test them out for defects and possible improvements, and the third

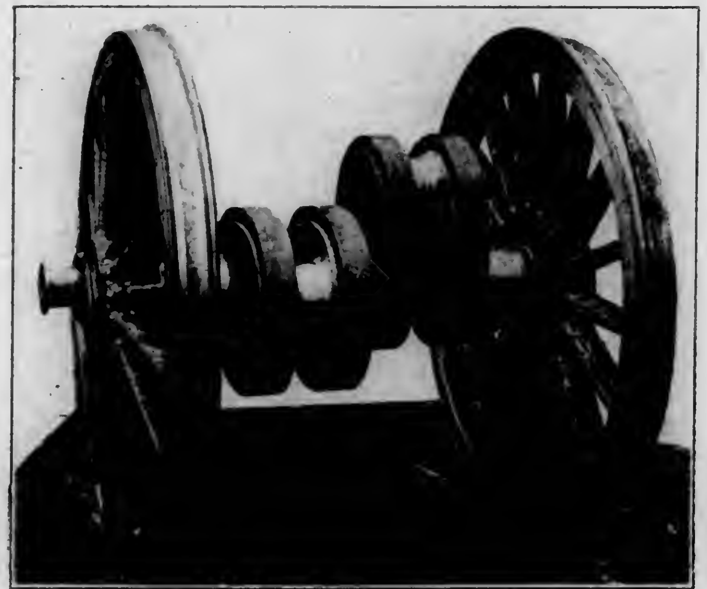


FIG. 1.—EARLY TYPE OF AMERICAN SOLID FORGED CRANK AXLE WITH BANDED REINFORCEMENT.

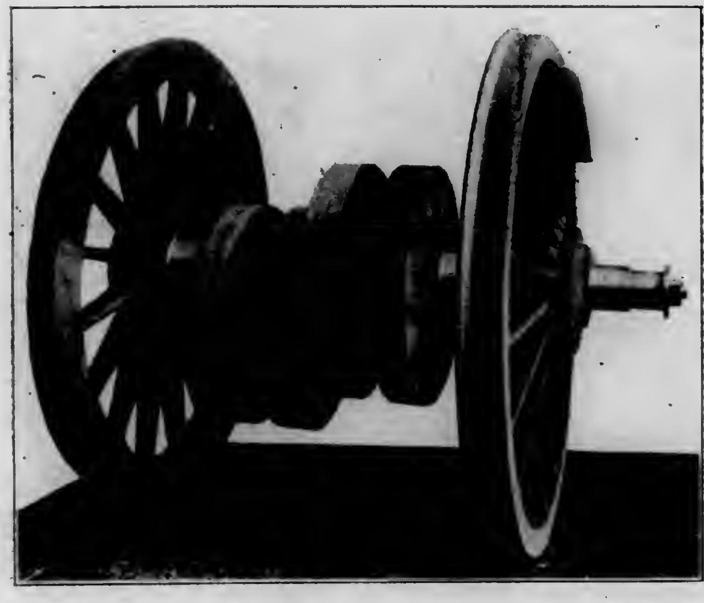


FIG. 1 A.—BUILT UP CRANK AXLE WITH FOUR CIRCULAR CHEEKS AND FIVE PINS.

year to actually construct and put into serviceable condition the twenty, or may be one hundred locomotives of the class that the building programme calls for. The result of this painstaking method is the production of a beautiful and fine machine, capable of the very best work within its limits of size, and economical both to operate and to maintain.

The refinement and standardization of American locomotive design is only beginning. One of the refinements is the balanced compound locomotive. Locomotives with cylinders between the frames, with crank axles, have been in successful and almost universal use in England and France for two generations, and are also used extensively in other European countries. As it is not customary to overload engines in England and on the Continent, nor keep them on the road when they require shop attention, and as great armies of men and inspectors are continuously employed keeping each engine in the pink of condition, the difficulties of rough American usage do not occur; when Americans attempt to use fine machines of these types under their rough conditions, without the care and attention given abroad, many bad features develop, among which may be mentioned the pounding, heating and rapid wearing out of round of the inside crank pins.

On European railways these pins are not allowed to run hot, nor to get into a condition where they do run hot, and what slight wear does result is taken up by either careful hand work, or by machines of which the accompanying illustrations (Figs. 4

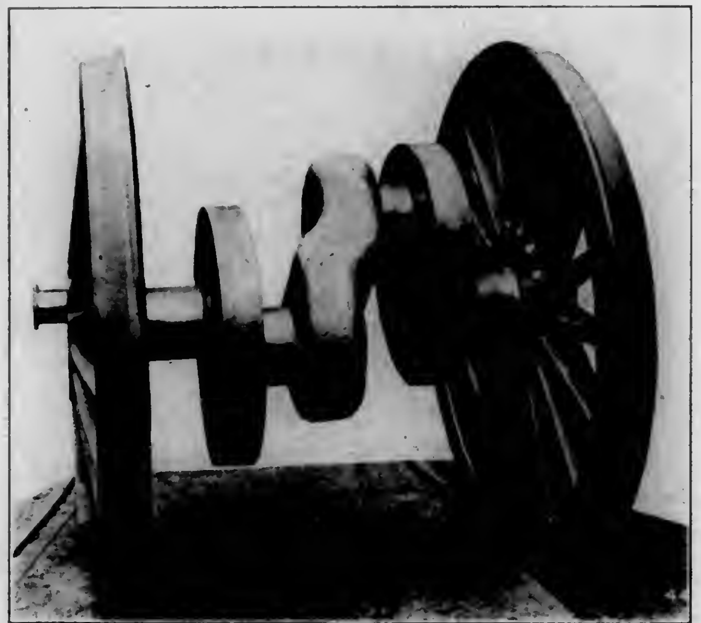


FIG. 2.—RECENT DESIGN OF BUILT UP SEMI-Z CRANK AXLE.

and 5) are a type. These machines require the wheels and axle to be removed from the engine.

With the introduction of the balanced compound, or inside crank locomotive, in this country, the early troubles incident to undue wear of these pins were met either by hand work, or, as there were no examples of European locomotive inside crank turning machines available in this country, by the construction of special types of crank pin turning machines, according to American standards of machine construction.

The limited space between the frames of an American locomotive, into which the high pressure cranks must be crowded, makes it impossible to use a crank of proper proportions to resist wear and prevent heating and pounding.

The rapidity with which the high pressure crank pins of a balanced compound locomotive are worn out of round is often surprising. This is especially true with large Pacific and Prairie type engines, which are usually equipped with long and very heavy bifurcated high pressure connecting rods, spanning the front driving axle, and connecting the high pressure crossheads with the middle or main driving axle. The extreme weight of this style of connecting rod causes the crank pins to be worn

* Santa Fe, Topeka, Kan.

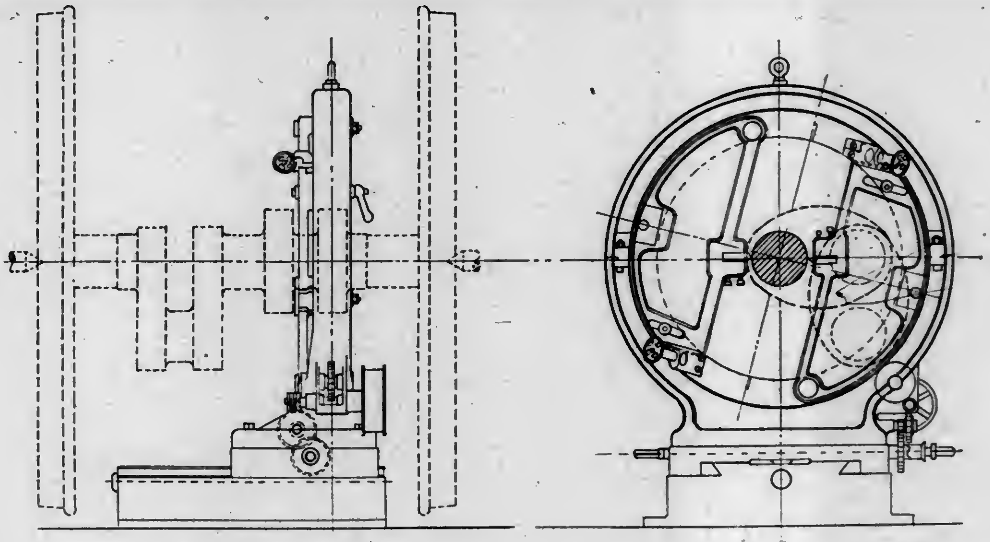


FIG. 4.—AN EUROPEAN CRANK AXLE RE-TURNING MACHINE.

away rapidly, as may be appreciated when it is known that 16 per cent. of all the engine failures occurring during a period of ten months service, to a class of fifty-one Pacific type balanced compound engines, were caused by some sort of trouble with the high pressure crank pins, or their connecting rods. These engines are used in heavy passenger service. Two new engines of this class were assigned to passenger service on a division having long and heavy grades; before they had been in service three months the inside crank pins were in such a condition that the back and high pressure rod brasses had to be renewed after every alternate round trip. Occasionally an extra strong set of brasses would survive two round trips and still remain intact, but they would be sure to come in after the third, either broken or burnt.

Since the first balanced compound engines were built, the locomotive builders of this country have made several improvements, which have lessened the inconvenience and expense of maintenance. One of these improvements is in the construction of the crank axle (Fig. 1). Most of the balanced compound locomotives, which have been built recently, are equipped with crank axles built up of from seven to nine separate pieces, pressed together. This construction permits of the removal and replace-

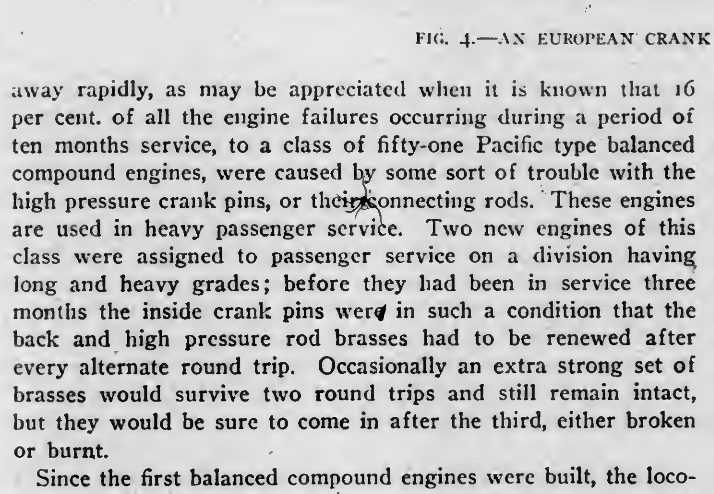


FIG. 3.—ILLUSTRATING THE WAY IN WHICH THE CRANK AXLE PINS WEAR OUT OF ROUND.

ment by a new part, of any member of the axle which may become broken or worn out. With this axle, a broken or worn out crank pin does not mean that the whole axle must be scrapped, as is necessary whenever anything goes wrong with the old solid forged axles. The axle shown in Fig. 2, known as the semi Z crank axle, is of this type, and is an improvement on the earlier form (Fig. 1a) which had two largs discs and a pin in place of the center forging.

A still later improvement, made by the Baldwin Locomotive Works in the design of some large Prairie type balanced compound engines, recently delivered to the Santa Fé System, consists of the elimination of the bifurcated rods. The high pressure cylinders of these engines are inclined several degrees to the horizontal and placed higher up in the cylinder casting than was formerly the practice. Such an arrangement obviates the necessity for the bifurcated rod, and makes it possible to use a straight high pressure connecting rod of minimum weight. That such improvements contribute largely toward preserving the contour of the crank pins of the engines to which they are applied, cannot be doubted, but they have only mitigated the evil, and so long as the balanced compound locomotive is used, motive power departments will have to deal with the problem of keeping the high pressure crank pins round enough to run cool and without pounding.

Fig. 3 is a sketch of the crank axle of an Atlantic type passenger engine, and shows the extent to which the inside crank pins very often become worn out of round. The crank pin is nearly always worn most on the quarter of its circumference nearest the center of the axle. In this case the left hand crank is worn away 3/16 in. at this point, while scarcely any wear at all can be detected on the opposite side of the pin. It is obvious that a workman, who was set to work to true up this pin with a file, would naturally do so by removing the smallest possible amount of metal, but by so doing he would increase the distance between the center of the crank pin and the center of the axle nearly ⅛ in. This would mean an increase of ¼ in. in the stroke of the engine. A little carelessness might also result in the crank pin being trued up at an incorrect quarter, with respect to the other cranks. Hence, the problem is not only one of making the crank pin round, but involves its restoration to the original throw and quarter.

Until recently a file was about the only tool on the market in America which could be used for this work. Several re-turning devices have been exploited at different times with more or less success. Figs. 4 and 5 show how the railways of Europe have been meeting the difficulty. The re-turning machine (Fig. 4) is a French production, which may be applied to an ordinary wheel lathe, the crank axle being supported by the centers of the lathe. The machine consists of a two piece, annular gear, which is made to revolve within an outer case, which is also made in two pieces. The cutting tools are carried by the two cross bars which are hinged at one end to the inside of the gear; the other end is fastened to the gear by means of an adjustable screw arrangement, which also provides a radial feed for the cutters. The power is applied by means of a belt passing over a pulley; a train of gears transmits the motion to the large annular gear. A set of auxiliary gears is provided which can be made to slide the upper part of the machine along dove-tailed ways on top of the base casting, thus effecting an axial feed. This is, no doubt,

THE SOLUTION OF THE CRANK AXLE PROBLEM

By Howard H. Lanning.*

American locomotives are of the simplest design, with large factors of safety in the proportions of their parts. As a consequence they can be built cheaply and quickly, and can be repaired by the crudest means. In Europe it has been customary to give much more thought and attention to these matters, and the claim is made that it takes three years to build a locomotive over there: one year to thoroughly work out the design in all its details; a second year to build one or two of the type and thoroughly test them out for defects and possible improvements, and the third

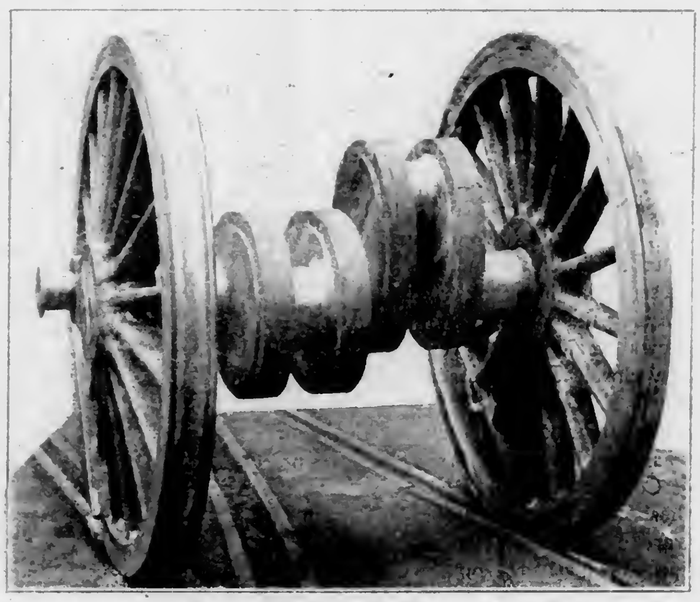


FIG. 1.—EARLY TYPE OF AMERICAN SOLID FORGED CRANK AXLE WITH BANDED REINFORCEMENT.

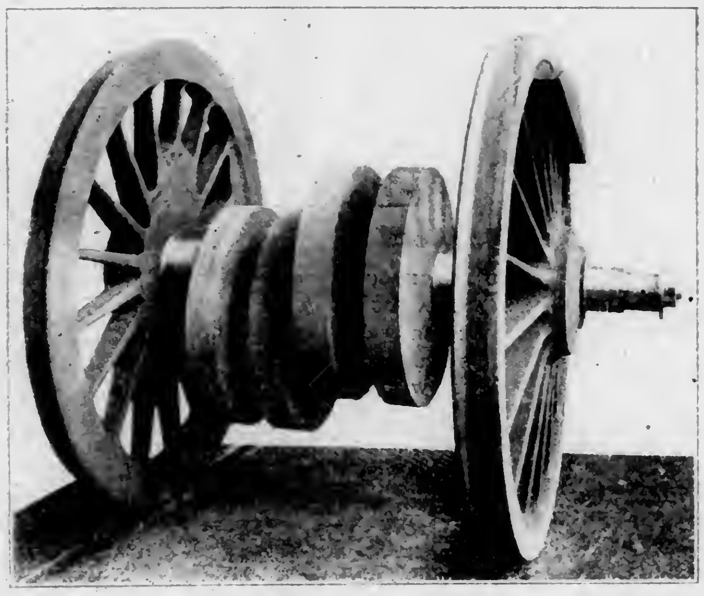


FIG. 3.—BUILT UP CRANK AXLE WITH FOUR CIRCULAR CHEEKS AND FIVE PINS.

year to actually construct and put into serviceable condition the twenty, or may be one hundred locomotives of the class that the building programme calls for. The result of this painstaking method is the production of a beautiful and fine machine, capable of the very best work within its limits of size, and economical both to operate and to maintain.

The refinement and standardization of American locomotive design is only beginning. One of the refinements is the balanced compound locomotive. Locomotives with cylinders between the frames, with crank axles, have been in successful and almost universal use in England and France for two generations, and are also used extensively in other European countries. As it is not customary to overload engines in England and on the Continent, nor keep them on the road when they require shop attention, and as great armies of men and inspectors are continuously employed keeping each engine in the pink of condition, the difficulties of rough American usage do not occur; when Americans attempt to use fine machines of these types under their rough conditions, without the care and attention given abroad, many bad features develop, among which may be mentioned the pounding, heating and rapid wearing out of round of the inside crank pins.

On European railways these pins are not allowed to run hot, nor to get into a condition where they do run hot, and what slight wear does result is taken up by either careful hand work, or by machines of which the accompanying illustrations (Figs. 4

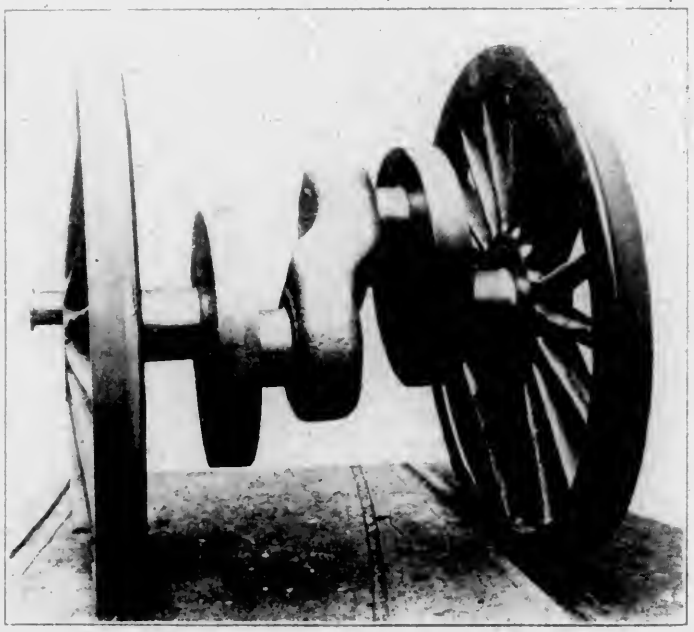


FIG. 2.—RECENT DESIGN OF BUILT UP SEMI-Z CRANK AXLE.

and 5) are a type. These machines require the wheels and axle to be removed from the engine.

With the introduction of the balanced compound, or inside crank locomotive, in this country, the early troubles incident to undue wear of these pins were met either by hand work, or, as there were no examples of European locomotive inside crank turning machines available in this country, by the construction of special types of crank pin turning machines, according to American standards of machine construction.

The limited space between the frames of an American locomotive, into which the high pressure cranks must be crowded, makes it impossible to use a crank of proper proportions to resist wear and prevent heating and pounding.

The rapidity with which the high pressure crank pins of a balanced compound locomotive are worn out of round is often surprising. This is especially true with large Pacific and Prairie type engines, which are usually equipped with long and very heavy bifurcated high pressure connecting rods, spanning the front driving axle, and connecting the high pressure crossheads with the middle or main driving axle. The extreme weight of this style of connecting rod causes the crank pins to be worn

* Santa Fe, Topeka, Kans.

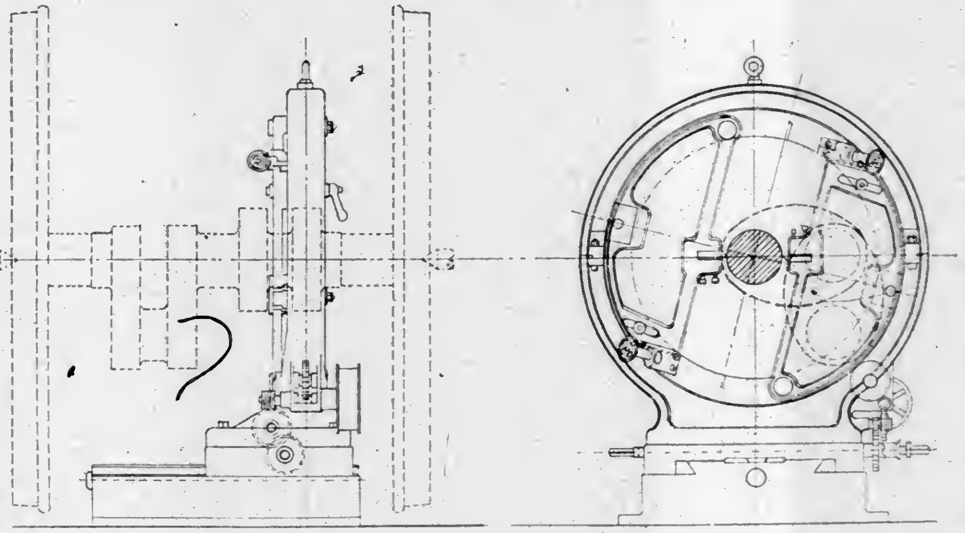


FIG. 4.—AN EUROPEAN CRANK AXLE RE-TURNING MACHINE.

away rapidly, as may be appreciated when it is known that 16 per cent. of all the engine failures occurring during a period of ten months service, to a class of fifty-one Pacific type balanced compound engines, were caused by some sort of trouble with the high pressure crank pins, or their connecting rods. These engines are used in heavy passenger service. Two new engines of this class were assigned to passenger service on a division having long and heavy grades; before they had been in service three months the inside crank pins were in such a condition that the back and high pressure rod brasses had to be renewed after every alternate round trip. Occasionally an extra strong set of brasses would survive two round trips and still remain intact, but they would be sure to come in after the third, either broken or burnt.

Since the first balanced compound engines were built, the locomotive builders of this country have made several improvements, which have lessened the inconvenience and expense of maintenance. One of these improvements is in the construction of the crank axle (Fig. 1). Most of the balanced compound locomotives, which have been built recently, are equipped with crank axles built up of from seven to nine separate pieces, pressed together. This construction permits of the removal and replace-

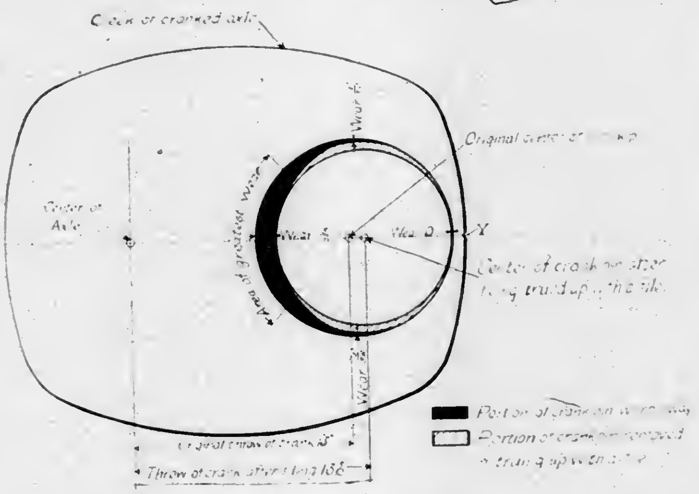


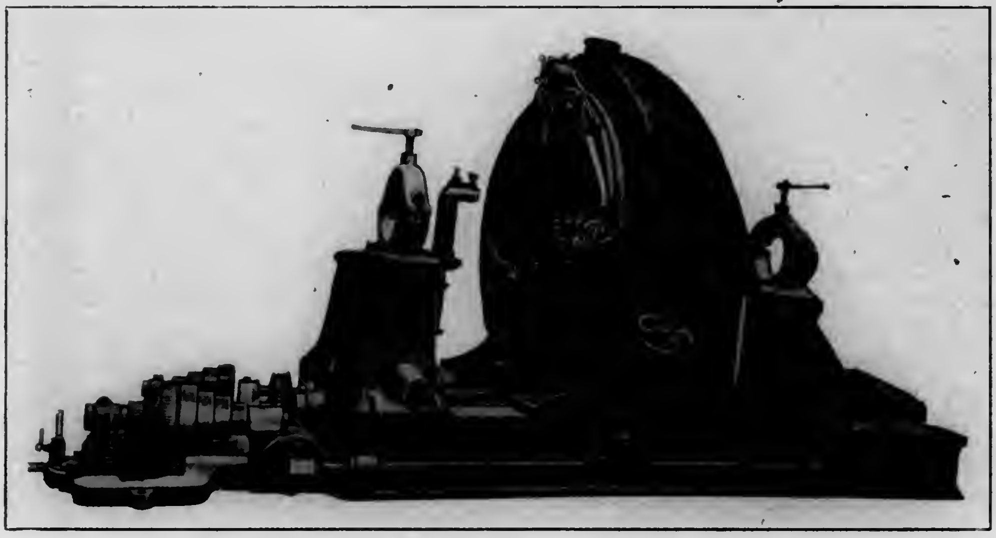
FIG. 3.—ILLUSTRATING THE WAY IN WHICH THE CRANK AXLE PINS WEAR OUT OF ROUND.

ment by a new part, of any member of the axle which may become broken or worn out. With this axle, a broken or worn out crank pin does not mean that the whole axle must be scrapped, as is necessary whenever anything goes wrong with the old solid forged axles. The axle shown in Fig. 2, known as the semi Z crank axle, is of this type, and is an improvement on the earlier form (Fig. 1a) which had two large discs and a pin in place of the center forging.

A still later improvement, made by the Baldwin Locomotive Works in the design of some large Prairie type balanced compound engines, recently delivered to the Santa Fé System, consists of the elimination of the bifurcated rods. The high pressure cylinders of these engines are inclined several degrees to the horizontal and placed higher up in the cylinder casting than was formerly the practice. Such an arrangement obviates the necessity for the bifurcated rod, and makes it possible to use a straight high pressure connecting rod of mininum weight. That such improvements contribute largely toward preserving the contour of the crank pins of the engines to which they are applied, cannot be doubted, but they have only mitigated the evil, and so long as the balanced compound locomotive is used, motive power departments will have to deal with the problem of keeping the high pressure crank pins round enough to run cool and without pounding.

Fig. 3 is a sketch of the crank axle of an Atlantic type passenger engine, and shows the extent to which the inside crank pins very often become worn out of round. The crank pin is nearly always worn most on the quarter of its circumference nearest the center of the axle. In this case the left hand crank is worn away 3/16 in. at this point, while scarcely any wear at all can be detected on the opposite side of the pin. It is obvious that a workman, who was set to work to true up this pin with a file, would naturally do so by removing the smallest possible amount of metal, but by so doing he would increase the distance between the center of the crank pin and the center of the axle nearly ⅛ in. This would mean an increase of ¼ in. in the stroke of the engine. A little carelessness might also result in the crank pin being trued up at an incorrect quarter, with respect to the other cranks. Hence, the problem is not only one of making the crank pin round, but involves its restoration to the original throw and quarter.

Until recently a file was about the only tool on the market in America which could be used for this work. Several re-turning devices have been exploited at different times with more or less success. Figs. 4 and 5 show how the railways of Europe have been meeting the difficulty. The re-turning machine (Fig. 4) is a French production, which may be applied to an ordinary wheel lathe, the crank axle being supported by the centers of the lathe. The machine consists of a two piece, annular gear, which is made to revolve within an outer case, which is also made in two pieces. The cutting tools are carried by the two cross bars which are hinged at one end to the inside of the gear; the other end is fastened to the gear by means of an adjustable screw arrangement, which also provides a radial feed for the cutters. The power is applied by means of a belt passing over a pulley; a train of gears transmits the motion to the large annular gear. A set of auxiliary gears is provided which can be made to slide the upper part of the machine along dove-tailed ways on top of the base casting, thus effecting an axial feed. This is, no doubt,



A POWERFUL EUROPEAN CRANK AXLE RE-TURNING MACHINE.

a powerful machine, but it has the disadvantage of being a stationary shop fixture, making it necessary to remove an axle from the engine in order to re-turn the crank pins.

The betterment department of the Santa Fé Railway has recently designed a portable crank axle re-turning machine which has proven very satisfactory, several of these machines being in successful operation in different shops on the Santa Fé System (Figs. 6, 7 and 8). This device weighs about three hundred pounds, and may be driven by any large air motor. It is so compact that it may be used on an inside, or high pressure crank pin, while the crank axle remains under the engine (Fig. 7). The only preliminary work required is the removal of the back end rod strap and brasses, and the shifting of the crosshead to the forward end of the stroke, in order that the connecting rod will be out of the way. This feature, in connection with the air motor drive (motor may be seen over top of crank axle in Fig. 7), makes it an extremely valuable tool in the roundhouse.

This device consists, as shown in Fig. 8, of a two-piece annular worm gear enclosed in the outer case, much the same as an eccentric is enclosed in the eccentric strap. This gear carries two high speed steel cutters, which are situated diametrically opposite each other, and are set in an inclined position so as to provide top rake. One end of these cutters is shaped to fit the fillet at the ends of the crank pin bearing, while the other end is backed off for clearance. Both cutters begin their cuts at the middle of the crank pin (the two cuts overlapping about ¼ in. at the middle) and are fed outward toward the fillets. Each of the tools may be fed either axially or radially to the crank pin. Both the axial and radial feeds may be operated automatically, by means of the star wheels, which as they revolve around the crank pin, engage specially shaped feeding pins. Any one of the feeds may be operated separately, or all may be used at the same time.

Fig. 6 shows the manner in which the feed pins engage the smaller star wheels which drive the axial feed screws. An ingenious centering device (indicated by the arrows, Fig. 7) makes it possible to adjust the machine to turn cranks of either 26 or 28 in. stroke.

To turn a crank pin with this machine the axle centers should first be accurately located on the inner surface of the cheeks, provided of course, that these centers are not already marked, as is always the case with the built up axle. A line should also be struck through the center of the crank pin and the center of the axle. The position of this line should be marked by a prick punch on the edge of the cheek, as indicated by the letter "Y" in Fig. 3. These points when once located, can be used for all subsequent re-turnings.

In setting up the machine the lower half is placed in position first, and is held in place by inserting the points of the large set screws of the centering device (indicated by the arrows, Fig. 7) into the axle center. The points of these screws must be previously adjusted to the distance from the center of the gear which corresponds with the throw of the crank, which insures the crank being restored to its proper throw. Next, the whole machine is assembled around the crank pin and bolted securely together. A small mark on the worm housing, on the upper half of the case, indicates the position of a line passing through the center of the gear and the center of the large screws of the

FIG. 6.—PORTABLE RE-TURNING MACHINE FOR INSIDE CRANKS.

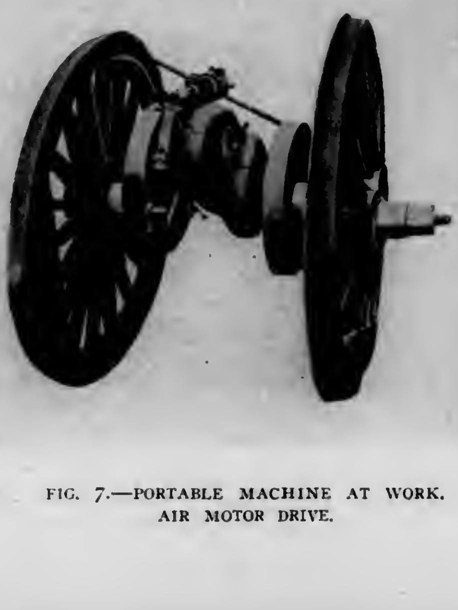


FIG. 7.—PORTABLE MACHINE AT WORK. AIR MOTOR DRIVE.

FIG. 8.—PORTABLE MACHINE WITH HALF OF CASE REMOVED.

centering device on the lower half of the case. The whole machine is shifted until this mark is exactly opposite the prick punch mark previously located on the corner of the disc, and is clamped there by means of pointed set screws located at convenient distances on the periphery of the case. This step takes care of the quartering of the axle. The sides of the gear are machined parallel to the plane of rotation, and hence offer a means of lining up the machine so that the pin will be turned perpendicular to the cheeks. A crank axle which has seen enough hard service to necessitate the re-turning of its high pressure crank pins is usually sprung more or less, hence the machine should always be lined up parallel to the cheek next to the driving box bearing, since this cheek is less likely to be sprung out of position.

The device is now ready to operate, and if due care has been exercised in the setting, the crank pin will not only be turned round and true, but it will be restored to its original stroke and quarter as well.

In the matter of cost of work done, this machine holds a decided advantage over any other method in use. It is possible to reduce the diameter of an eleven inch crank pin 5/16 in. in six hours. This includes all the time used in setting up the machine, carrying tools to and from the tool room, and all preliminary operations except the locating of axle center. However, there are a great many little things which could happen to delay the job, and which may increase the total time to eight hours. The operator should be a good machinist, and he will need the assistance of a helper or laborer for about two hours, when setting up the machine. About one hour's filing with a fine cut file is usually required after turning in order to put the pin in first-class condition.

The following figures show the saving over hand filing, which is made possible by the use of this device:

The first cost of the machine is about	$550.00
Cost of air motor of sufficient size to operate the machine	100.00
Total	$650.00
Machine charge, 10c. per hour for six hours	$0.60
Operator's wages at 34c. per hour, six hours	2.04
Helper's wages at 17c. per hour, two hours	0.34
One hour's filing	0.34
Total cost turning and filing one crank pin	$3.32

One man could probably do the same amount of work with a file in about three days, or thirty hours. Thirty hours filing at 34 cents per hour would cost $10.20. To do this job by hand under an engine is hard and tedious work, and it is impossible to get the pin perfectly true, besides there are other disadvantages.

Comparing the two methods we have:

Cost of filing one crank pin	$10.20
Cost of turning and filing one crank pin	3.32
Saving effected by use of machine	$6.88
Per cent. saving	69

The first operation connected with truing up an inside crank pin in a stationary machine, is to remove the crank axle and wheels from the engine. To remove a pair of main drivers from a balanced compound locomotive, and replace them again with the drop pit arrangement, used in most roundhouses, requires the services of a machinist and his helper for about 18 hours and the assistance of an additional helper is needed for about 8 hours. A fair estimate of the total cost of a drop pit jack equipment would be $500, and 30 per cent. per annum is a common rate of surcharge for such equipment. On this basis, the hourly rate of surcharge would be 5 cents.

The following figures illustrate the cost of removing a pair of drivers with crank axle from a locomotive and replacing them again after having been turned and trued up. For the sake of conservatism the surcharge rates given in connection with the operation of the stationary machine are much lower than it is good practice to place them, while the rate given for the portable machine is based on the actual surcharge placed upon it:

Wages of machinist at 34c. per hr. for 18 hrs	$6.12
" " helper " 17c. per hr. for 18 hrs	3.06
" " " " 17c. per hr. for 8 hrs	1.36
Total labor cost of removing and replacing axle	$10.54
Drop pit jack charge at 5c. per hr. for 18 hrs	.90
Total cost of removing and replacing axle	$11.44

To deliver the axle and its wheels from the drop pit to the machine will in most cases require the services of 6 laborers for a half hour and the same time to return the axle and wheels from the machine to the drop pit—wages, 6 laborers at 15 cents per hour for 1 hour, $0.90.

Assuming that an inside crank pin can be trued up in four hours time, and that the cost of the machine is $1,100, 20 per cent. of which value is charged annually to cover machine charges, supervision, etc., constituting the "surcharge," the actual cost of re-turning one inside crank pin would be as follows:

Machine charge at 7c. per hour for 4 hours	$0.28
Operator's wages at 34c. per hour for 4 hours	1.64
Operator's helper's wages at 17c. per hour for 1 hour	.17
Cost of re-turning one crank pin	$2.09

Summing up the foregoing we have:

Cost of removing and replacing axle in engine	$11.44
Cost of handling axle between drop pit and machine	.90
Cost of turning crank pin	2.09
Minimum total cost of turning up one crank pin on stationary machine	$14.43
Total cost of turning up one crank pin on portable machine	3.32
Difference in favor of portable machine	$11.11
Per cent. saving	79

The above figures indicate only the possible saving on the cost of the work. It often happens that an engine is held in the roundhouse solely on account of work on the high pressure crank pins. In such a case the saving effected by the machine, over hand work, would be increased by the amount the engine would earn during the time saved by the machine, and this would amount to from $4 to $10 per hour of detention from earning service.

Another saving which is effected by the use of this machine, and by far the largest, is the cost of delays to traffic, due to engine failures and damage to equipment which might be prevented to a considerable extent if some rapid and accurate means of truing up high pressure crank pins were provided in the roundhouse. The balanced compound locomotive has achieved a great success abroad because it is one of the fastest, most powerful, most economical, and at the same time easiest on road bed and track, of any type of engine. American railroad men have looked rather askant at the complication involved in this type of construction, and they have foreseen the troubles that would be incident to the use of crank axles. Now that a device has been perfected for correcting, and to a large extent overcoming and eliminating these troubles, the problem of the crank axle, from a mechanical and operative point of view, may be said to be solved for American railroad practice, thus enabling railroad managers to take advantage of this type of high speed and high power motive equipment.

The machine here described is in use at a number of the shops and roundhouses on the Santa Fé, and is being manufactured by The Tool & Railway Specialty Manufacturing Company of Atchison, Kansas.

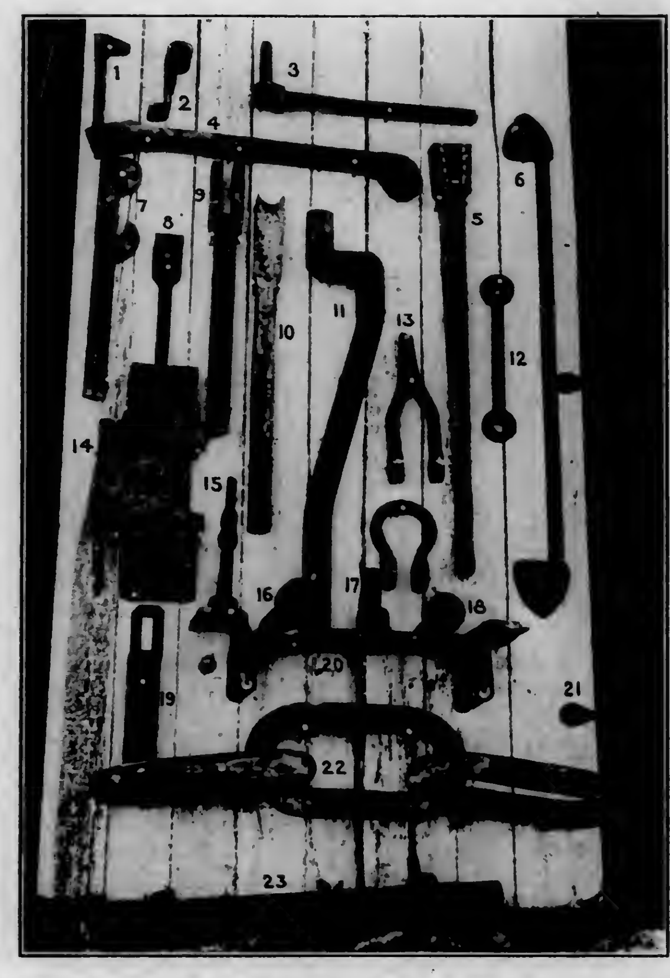
FUEL ECONOMY.—In speaking before a meeting of the American Society of Mechanical Engineers, on the conservation of the nation's fuel supply, Dr. W. F. M. Goss showed that the necessary steps to secure economy of coal were:

a. Scientific research for the establishment of facts.
b. Practical development of the facts thus developed on a scale which will convince men that there is profit, direct and indirect, in a better practice.
c. Restrictive legislation which will protect the public from the competition of unscrupulous men.
d. Effective inspection which will secure enforcement of laws. The process must begin with education—not with coercion.

FORGING AT THE GREAT NORTHERN RAILWAY SHOPS.*

In the Great Northern Railway shops, St. Paul, Minn., are three forging machines, one 4-in. Ajax, one 2½-in. Blakeslee and one 1½-in. Ajax. In addition there are two bolt heading machines, a 1¼-in. Ajax and a small Blakeslee machine. A few of the articles which are made in these machines—selected for their novelty and clean-cut finish—are shown in one of the illustrations. All of these pieces come from the machine just as they are shown, with the exception of No. 5, the handle of which is drawn out after the socket is made on the machine. The method of making these parts is briefly described as follows:

No. 1 is a hook bolt made from ¾-in. round stock. About 6



EXAMPLES OF MACHINE FORGINGS MADE AT THE GREAT NORTHERN SHOPS.

in. at the end of the bar is first upset to ¾ in. square. It is then reheated and upset, as shown.

No. 2, a car apron hinge, is made in one heat with two movements.

No. 3, a gate hinge, is made from 1-in. stock in two heats with three movements.

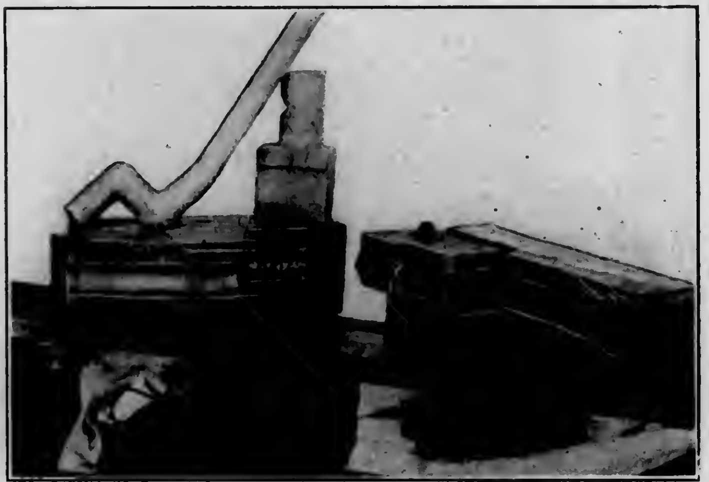
No. 4, a pilot brace, is made from 1½-in. stock in one heat and two movements for each end.

No. 5, grate shaker lever, is made from 1 x 2-in. stock; the socket end is made in one heat and two movements. The end is first upset and the socket is then formed. The handle is drawn out under a steam hammer.

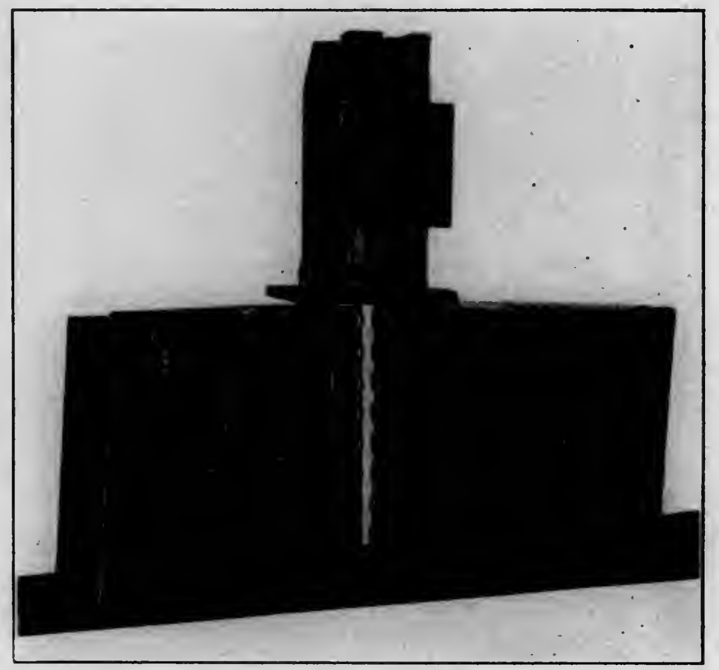
No. 6 is a tank hand-hold, each end of which is made in one heat and two movements.

* Articles describing the machine forging work done at the Collinwood shops of the Lake Shore & Michigan Southern Railway may be found on page 142 of the April, 1906, issue: page 234, June, 1906; page 192, May, 1907, and page 341, September, 1907. Similar work which is being done at the South Louisville shops of the Louisville & Nashville Railroad was described on page 125 of the April, 1907, issue. Examples of work done by forging machines and bulldozers at the Topeka shops of the Santa Fe were illustrated on page 463 of the December, 1906, issue.

No. 7 is a tie bar made from 1½-in. round stock. The inner lug is first upset in the lower die, after which the bar is reheated and the end lug is formed in the upper die. The slot is then punched to suit the size of the rail, by a side movement of the machine. This method is much more satisfactory than that of having the operator step on top of the machine and hold the bar in a vertical position while the slot is punched by the header. Forty thousand of these bars were made last year, at the rate of 250 complete bars per day of ten hours. During that time no repairs were made to either the dies or punch. The dies



DIES AND FORMER FOR NO. 11.



DIES FOR MAKING NO. 14.

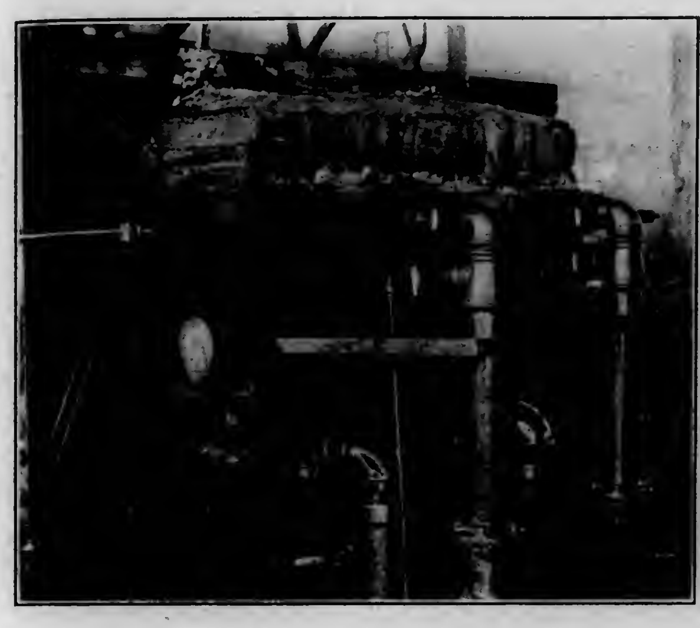
and punch are cooled by a stream of water which runs constantly while the machine is in operation.

No. 8 is a brake beam guide pin made from 1½ x 2½-in. stock. The shank is drawn in the first heat and the gib is bent and a hole punched in one movement in the second heat.

Nos. 9 and 10 show the jaw and strap ends of switch connection rods which are made from 1½-in. round stock.

No. 11 is a switch stand crank which is made from 1⅞-in. round stock in one heat and two movements. The dies for making this piece are shown in one of the illustrations and consist of three pieces. A sliding block is attached to the side of one of the dies. The two dies closing together sidewise bend the stock and the header striking the sliding block completes the piece.

No. 12 is a clevis. It is made from round stock, each



APPLICATION OF SPECIAL CRUDE OIL BURNER TO LARGE AND SMALL FURNACES.

end requiring one heat and two movements. The first movement upsets the end into a round disk, the second punches the hole. After the two ends are prepared in this way the piece is bent on a small bulldozer to the shape shown just below No. 13 and just above Nos. 17 and 18 in the illustration.

No. 13 is a brake hanger. The ends are made in the same way as those of the clevis, from ¾ x 1-in. stock. After the eyes are formed two pieces are welded together on the machine; they are then spread apart to the required width.

No. 14, a follower plate, is forged from 1½ x 7-in. material. The dies for making these plates are shown in one of the photos. One movement of the machine shears the plate to size and the second movement forms the boss. It will be seen that those parts of the dies which shear the plate to shape have the cutting edges tapered at opposite angles, thus reducing the strain on the machine to a minimum, while they are shearing the piece.

Nos. 15, 16, 17 and 18 show different size socket wrenches. These are made in all sizes, with either hexagon or square heads, in one heat and two movements. They are said to be made more quickly than the ordinary engine bolt.

No. 19, a car door hasp, is made in one heat and two movements.

No. 20, a carrier iron, is made from ⅝ x 5-in. stock in one heat and three movements.

No. 21 is a grab iron which is made from ⅝-in. round stock. One heat and two movements are required for each end. The end is upset in the first movement and the hole punched in the second. The bend is formed by a side motion of the dies.

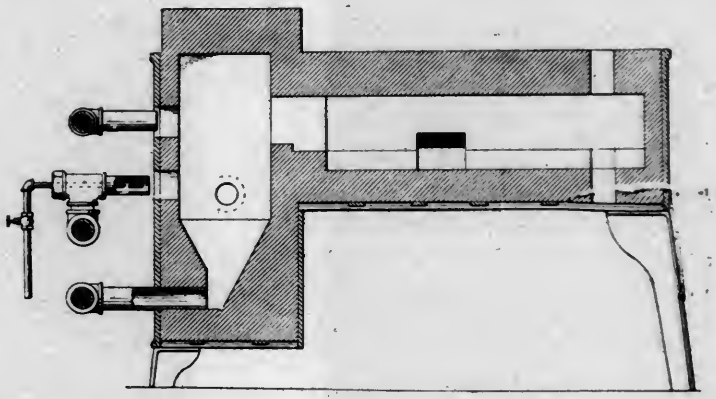
No. 22 is a three-link coupler for wrecking outfits. It is made from 1½-in. stock and is bent and welded on the machine.

No. 23, a brake fulcrum, is made in one heat.

The larger pieces, such as the switch stand crank, the follower plates and the shaker lever, are made on the 4-in. machine. The smaller parts are made on the 2½ and 1½-in. machines.

The rate at which the work can be turned out on these forging machines is of course limited largely by the rate at which the furnaces can heat the material. A special arrangement of burners is used in the furnaces in this shop, which has been patented by Mr. Yoerg, the shop superintendent, and Mr. Treacy, the master blacksmith. These burners not only furnish perfect combustion, thus heating the material in a shorter time and with a minimum amount of oil, but will do this with the cheapest and dirtiest crude oil on the market, costing from three to three and a half cents per gallon. This is accomplished by using a triple blast, as shown on the drawing. The oil is sprayed under pressure through the central burner and strikes the opposite wall of the combustion chamber, separating it into fine particles. These are ignited and the blast from below mixes with them, thus assisting the processes of combustion, and carries them to the upper part of the chamber. Here they meet the upper blast which insures complete combustion and forces a clear white flame of intense heat on the material in the heating chamber.

The pipes are all outside the combustion chamber, and are readily accessible for cleaning or repairs. They are said, however, to require practically no attention or expense for these items. No carbon formation at all can be found in the furnaces in this shop. The third or top blast may be made to drive the flame a long distance, thus making it possible to heat material of such length that two ordinary burners would be required. The photographs show the blast pipes in detail as attached to one of the larger furnaces, requiring two sets of burners; also a similar arrangement applied to one of the smaller furnaces. Fourteen of these furnaces are in operation in the shop, also several portable rivet heating furnaces.



YOERG-TREACY BLAST ARRANGEMENT FOR CRUDE OIL FURNACE.

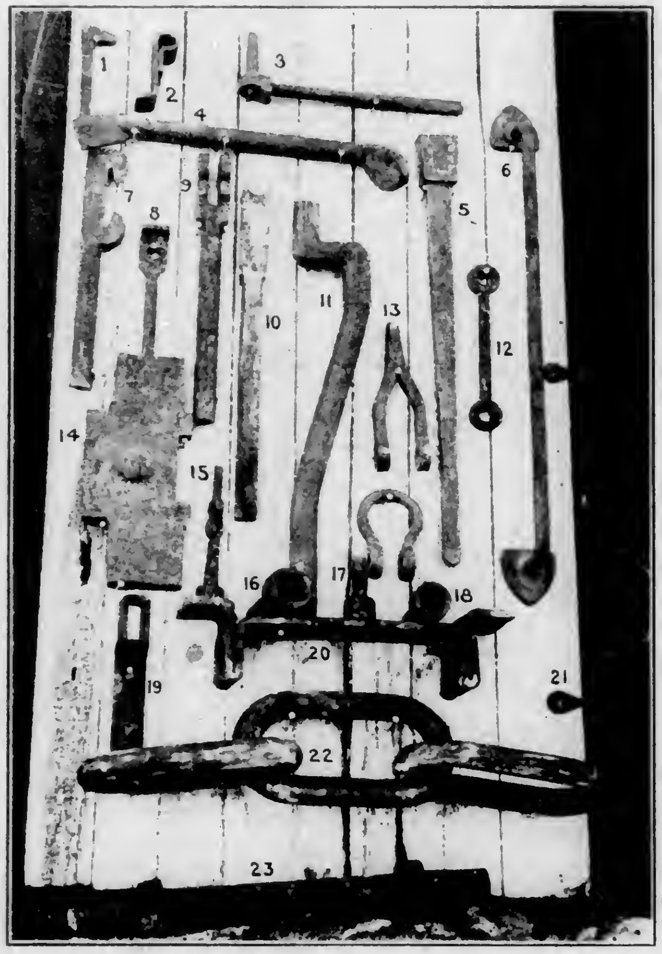
We are indebted for information to H. Yoerg, shop superintendent, and J. Treacy, master blacksmith.

OUR FUEL SUPPLY.—All estimates of future consumption and destruction of coal are liable to error, yet making all reasonable allowance, unless there be careful husbanding, or revolutionizing inventions, or some industrial revolution comes which cannot now be foreseen, the greater part of that estimated 2,500,000,000,000 tons of coal forming our original heritage will be gone before the end of the next century, say 200 years hence.—*Andrew Carnegie at the Governors' Conference.*

FORGING AT THE GREAT NORTHERN RAILWAY SHOPS.*

In the Great Northern Railway shops, St. Paul, Minn., are three forging machines, one 4 in. Ajax, one 2½-in. Blakeslee and one 1½ in. Ajax. In addition there are two bolt heading machines, a 1¼-in. Ajax and a small Blakeslee machine. A few of the articles which are made in these machines—selected for their novelty and clean cut finish—are shown in one of the illustrations. All of these pieces come from the machine just as they are shown, with the exception of No. 5, the handle of which is drawn out after the socket is made on the machine. The method of making these parts is briefly described, as follows:

No. 1 is a hook bolt made from ¾ in. round stock. About 6



EXAMPLES OF MACHINE FORGINGS MADE AT THE GREAT NORTHERN SHOPS.

in. at the end of the bar is first upset to ¾ in. square. It is then reheated and upset, as shown.

No. 2, a car apron hinge, is made in one heat with two movements.

No. 3, a gate hinge, is made from 1-in. stock in two heats with three movements.

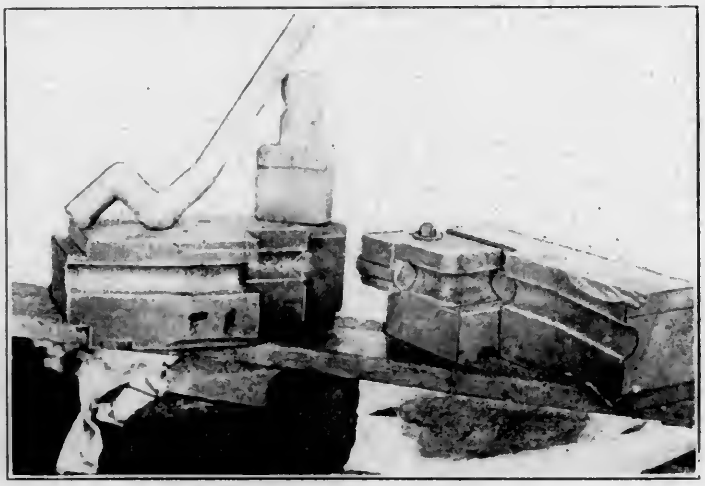
No. 4, a pilot brace, is made from 1½-in. stock in one heat and two movements for each end.

No. 5, grate shaker lever, is made from 1 x 2-in. stock; the socket end is made in one heat and two movements. The end is first upset and the socket is then formed. The handle is drawn out under a steam hammer.

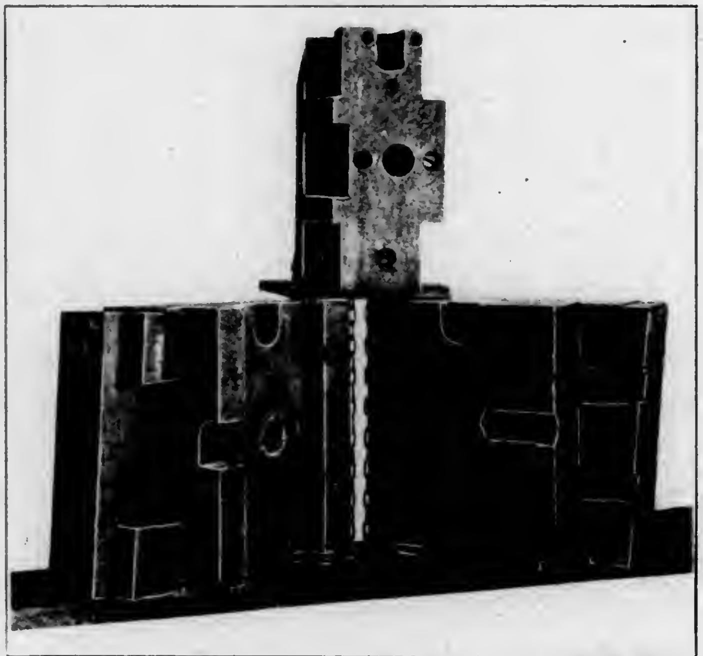
No. 6 is a tank hand-hold, each end of which is made in one heat and two movements.

* Articles describing the machine forging work done at the Collinwood shops of the Lake Shore & Michigan Southern Railway may be found on page 149 of the April, 1906, issue; page 231, June, 1906; page 192, May, 1907, and page 311, September, 1907. Similar work which is being done at the South Louisville shops of the Louisville & Nashville Railroad was described on page 125 of the April, 1907, issue. Examples of work done by forging machines and bulldozers at the Topeka shops of the Santa Fe were illustrated on page 463 of the December, 1906, issue.

No. 7 is a tie bar made from 1½-in. round stock. The inner lug is first upset in the lower die, after which the bar is reheated and the end lug is formed in the upper die. The slot is then punched to suit the size of the rail, by a side movement of the machine. This method is much more satisfactory than that of having the operator step on top of the machine and hold the bar in a vertical position while the slot is punched by the header. Forty thousand of these bars were made last year, at the rate of 250 complete bars per day of ten hours. During that time no repairs were made to either the dies or punch. The dies



DIES AND FORMER FOR NO. 11.



DIES FOR MAKING NO. 14.

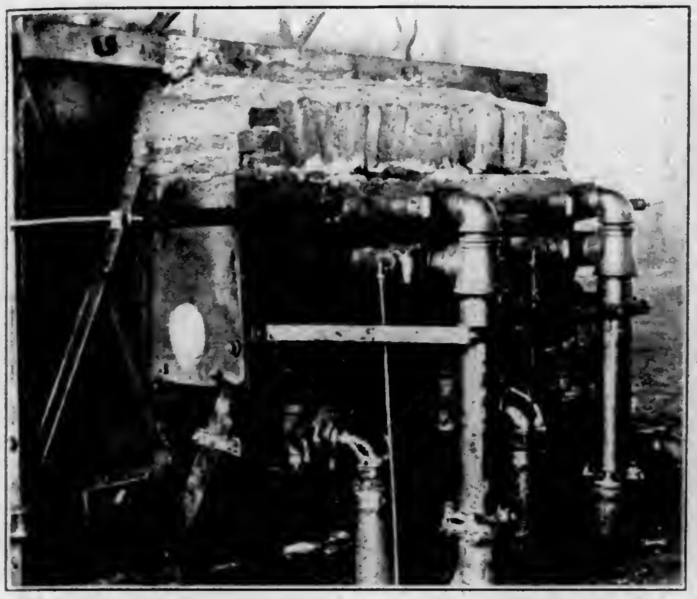
and punch are cooled by a stream of water which runs constantly while the machine is in operation.

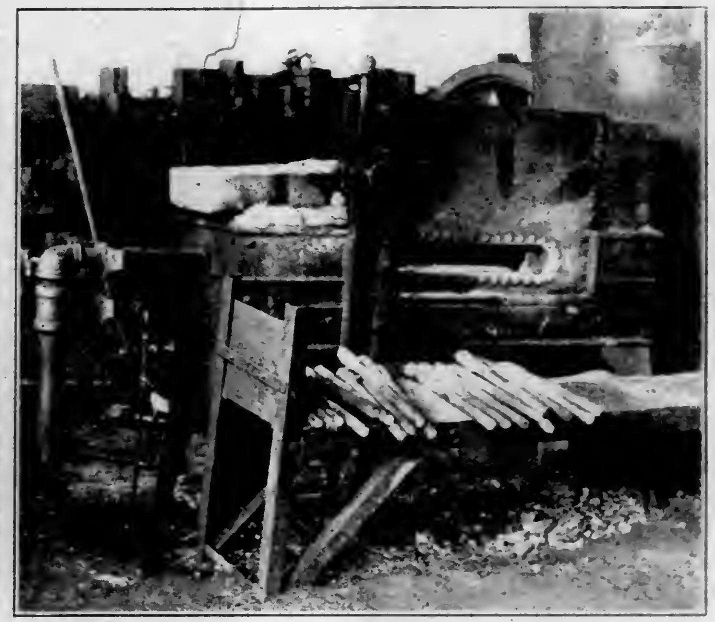
No. 8 is a brake beam guide pin made from 1½ x 2½-in. stock. The shank is drawn in the first heat and the gib is bent and a hole punched in one movement in the second heat.

Nos. 9 and 10 show the jaw and strap ends of switch connection rods which are made from 1½-in. round stock.

No. 11 is a switch stand crank which is made from 1⅞-in. round stock in one heat and two movements. The dies for making this piece are shown in one of the illustrations and consist of three pieces. A sliding block is attached to the side of one of the dies. The two dies closing together sidewise bend the stock and the header striking the sliding block completes the piece.

No. 12 is a clevis. It is made from round stock each





APPLICATION OF SPECIAL CRUDE OIL BURNER TO LARGE AND SMALL FURNACES.

end requiring one heat and two movements. The first movement upsets the end into a round disk, the second punches the hole. After the two ends are prepared in this way the piece is bent on a small bulldozer to the shape shown just below No. 13 and just above Nos. 17 and 18 in the illustration.

No. 13 is a brake hanger. The ends are made in the same way as those of the clevis, from 3/4 x 1-in. stock. After the eyes are formed two pieces are welded together on the machine; they are then spread apart to the required width.

No. 14, a follower plate, is forged from 1 1/2 x 7-in. material. The dies for making these plates are shown in one of the photos. One movement of the machine shears the plate to size and the second movement forms the boss. It will be seen that those parts of the dies which shear the plate to shape have the cutting edges tapered at opposite angles, thus reducing the strain on the machine to a minimum, while they are shearing the piece.

Nos. 15, 16, 17 and 18 show different size socket wrenches. These are made in all sizes, with either hexagon or square heads, in one heat and two movements. They are said to be made more quickly than the ordinary engine bolt.

No. 19, a car door hasp, is made in one heat and two movements.

No. 20, a carrier iron, is made from 5/8 x 5-in. stock in one heat and three movements.

No. 21 is a grab iron which is made from 5/8-in. round stock. One heat and two movements are required for each end. The end is upset in the first movement and the hole punched in the second. The bend is formed by a side motion of the dies.

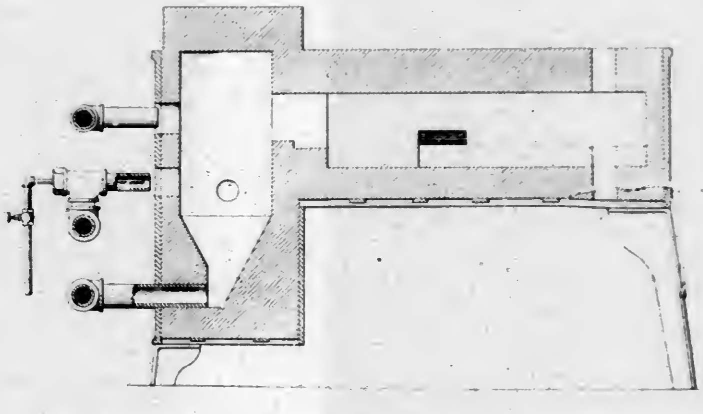
No. 22 is a three-link coupler for wrecking outfits. It is made from 1 1/2-in. stock and is bent and welded on the machine.

No. 23, a brake fulcrum, is made in one heat.

The larger pieces, such as the switch stand crank, the follower plates and the shaker lever, are made on the 4-in. machine. The smaller parts are made on the 2 1/2 and 1 1/2-in. machines.

The rate at which the work can be turned out on these forging machines is of course limited largely by the rate at which the furnaces can heat the material. A special arrangement of burners is used in the furnaces in this shop, which has been patented by Mr. Yoerg, the shop superintendent, and Mr. Treacy, the master blacksmith. These burners not only furnish perfect combustion, thus heating the material in a shorter time and with a minimum amount of oil, but will do this with the cheapest and dirtiest crude oil on the market, costing from three to three and a half cents per gallon. This is accomplished by using a triple blast, as shown on the drawing. The oil is sprayed under pressure through the central burner and strikes the opposite wall of the combustion chamber, separating it into fine particles. These are ignited and the blast from below mixes with them, thus assisting the processes of combustion, and carries them to the upper part of the chamber. Here they meet the upper blast which insures complete combustion and forces a clear white flame of intense heat on the material in the heating chamber.

The pipes are all outside the combustion chamber, and are readily accessible for cleaning or repairs. They are said, however, to require practically no attention or expense for these items. No carbon formation at all can be found in the furnaces in this shop. The third or top blast may be made to



YOERG-TREACY BLAST ARRANGEMENT FOR CRUDE OIL FURNACE

drive the flame a long distance, thus making it possible to heat material of such length that two ordinary burners would be required. The photographs show the blast pipes in detail as attached to one of the larger furnaces, requiring two sets of burners; also a similar arrangement applied to one of the smaller furnaces. Fourteen of these furnaces are in operation in the shop, also several portable rivet heating furnaces.

We are indebted for information to H. Yoerg, shop superintendent, and J. Treacy, master blacksmith.

OUR FUEL SUPPLY.—All estimates of future consumption and destruction of coal are liable to error, yet making all reasonable allowance, unless there be careful husbanding, or revolutionizing inventions, or some industrial revolution comes which cannot now be foreseen, the greater part of that estimated 2,500,000,000,000 tons of coal forming our original heritage will be gone before the end of the next century, say 200 years hence.—*Andrew Carnegie at the Governors' Conference.*

UNIVERSAL STANDARD FREIGHT CARS

Millions of dollars worth of surplus material is being carried at the freight car repair points because of the lack of universal standardization. A few months ago, during the scarcity of freight cars, thousands of them were held out of service on foreign lines for considerable periods because of the necessity of securing material from the home road for making proper repairs.

The American Railway Association and the Master Car Builders' Association have done splendid work in the way of standardization, but they have hardly more than started this work. Much remains to be done.

The following letter was recently sent to a number of leading railway officials: "Would it not be desirable for the American Railway Association to advise the Master Car Builders' Association to design, in detail, a series of standard freight cars, of such types and capacities as are best suited for different conditions of service? The general adoption of such cars would facilitate the making of repairs, increase the efficiency of the cars and reduce the expense of maintenance. Is there any important reason why this should not be done?"

Extracts from some of the replies to this letter are as follows:

Union Pacific System—Southern Pacific Company.

I do not know of any reason whatever why standard freight cars, of types and capacities suited to different conditions of service, should not be adopted by the American roads. There are many very strong reasons why standards should be adopted. Such practice would facilitate the making of repairs and would reduce largely the amount of idle capital tied up in repair parts accumulated at junction points, would increase the efficiency of cars largely by reducing the time that they are in shops, and would reduce the actual cost, as the parts could be kept in stock by car builders, instead of having to let contracts for castings, forgings, etc., after receipt of orders.

The adoption of a standard car, moreover, would facilitate the formation of a freight car pool, to which I believe we shall ultimately be driven by interchange conditions.

The Master Car Builders have been able to agree on but a limited number of standards, and *I am strongly of the opinion that the initiative in this matter should be taken by the executive heads of some ten or twelve large systems. If these gentlemen should issue positive instructions to their car builders to agree on standards, and should then adopt them, the problem would be solved.*

J. Kruttschnitt,
Director of Maintenance and Operation.

Canadian Pacific Railway Co.

I do not believe any practical advantage would be gained by the Master Car Builders' Association designing a series of standard cars. It is true that several large systems have determined on standards applicable to all roads under their control, which is to a certain extent an indication that there is no need for the large variety of cars that they have been constructing, but on the other hand this same action has established a number of different standards which it would be impracticable to revise and unite into one on all the roads for many years to come.

I consider that the good of the railways is better served by the Master Car Builders' Association steadily developing certain standards of details which it is practicable to adopt throughout the country. They have done a large amount of work in this way and no doubt will be able to do more. Draft gear attachments and hand brake rigging no doubt could be better standardized than they are. I see no reason why certain standard trucks of various capacities, having several heights for each size of truck, should not be designed, and with some prospect of their final adoption; but the designing of an entire car and calling it the Master Car Builders' standard would mean in all probability such a standard being neglected until one line after another had introduced improvements which would cause them to prefer their own design to that of the Master Car Builders' Association.

I am doubtful also whether even at present the design of a steel car is sufficiently determined to enable a final standard to be arrived at, and the whole course of things is opposed to all roads converging on one design. Different roads start out with different ideas and gradually develop these until they are in a more or less perfect state, and during this time they have constructed large numbers of cars, as a rule along more or less uniform lines of construction, but each road working along a rather different system to obtain final results.

The ultimate result is a number of varying designs each of which has been brought to a state of practical perfection. I do not believe this method of evolution can be arrested or modified by any action of the Master Car Builders' Association.

H. H. Vaughan, Asst. to the Vice-Pres.

The Atchison, Topeka and Santa Fe System.

Undoubtedly it would be beneficial if all of the cars in the United States were constructed according to a common standard. It would also be beneficial if an agreement with respect to future standards of construction could be reached, but I do not believe it is possible.

The American Railway Association some time ago considered this matter very fully and decided upon certain standards of length, breadth, and height of box car bodies, which they recommended. I have never adopted these recommendations, because I believe that the width and height of box cars should be the maximum that clearance permits, and that the length should be regulated by the character of the traffic carried. Then there is a great diversity of opinion as regards carrying capacity, there being advocates of 60,000, 80,000 and 100,000 pounds. I believe in a capacity of 70,000. If an 80,000 pound car is built, the percentage of dead weight will be practically the same as that of a 100,000 pound car, the difference in weight being, say, 4,000 pounds. There should not be more than 400 pounds difference between a 60,000 and 70,000 pound car. Cars of 100,000 pounds capacity are not economical for use on western roads, or in sections of the country where heavy loading is not the rule. For instance, the average loading of our cars, we will say, is 20 tons. I can see no use, in fact it is very uneconomical, to haul 3,600 pounds additional dead weight for the sake of having this extra capacity, which can seldom be utilized. To attempt to standardize the equipment of the United States along the lines suggested by you is, I fear, impracticable. I know of no one else who has built any 70,000 pound cars, yet we would not care to depart from the standards adopted, and I suppose every manager in the country entertains similar views about the type of car he is building.

Moreover, there is a great diversity of opinion about underframing. Some believe in the steel underframe, some do not. At present I am inclined to favor a composite underframe, reinforcing the center sills with channels, between which the draft rigging can be inserted, fastening them to the wooden sills by bolts and tying the whole construction together with truss rods which extend through cast plates, which cover the wooden end sills. The wooden superstructure of the center sills, or the upper member, prevents corrosion of the lower member by protecting it from drippings from sulphurous coal, etc. In case cars are wrecked center sills rarely sustain any damage, whereas, the steel side sills are almost always very badly distorted. Again, there is a difference of opinion as to whether steel sills should be of pressed, or built of structural material. I favor the latter construction.

After long and tedious argument the result would probably be some further inoperative recommendation as to general dimensions. I do not think that the plan you suggest is at all practicable.

J. W. Kendrick, Second Vice-Pres.

The American Railway Association.

While I think the suggestion is undoubtedly a good one, I am very apprehensive as to whether it would be possible to accomplish anything in that direction under existing conditions.

As you are aware, the Master Car Builders' Association has been endeavoring for several years to secure a standard design for a drawbar coupler, in order to obviate the necessity for carrying in stock a large number of different parts for the purpose of making repairs to foreign cars.

While this is gradually being brought about, it will probably be some years before any considerable improvement is made in that direction; and, in the meantime, I do not think it will be feasible to do anything in the way of adopting a standard car, such as you suggest.

W. C. Brown, President.

GREAT NORTHERN RAILWAY COMPANY.

There is such a difference in the traffic handled in different localities that a car which will suit one place will not suit another. Custom has also a great deal to do with the pattern and size of cars.

JAMES J. HILL, Chairman of the Board.

THE BALTIMORE & OHIO RAILROAD COMPANY.

We are of the opinion that nothing would be gained by establishing standards for all details of freight cars. A great deal has already been accomplished by the Master Car Builders' Association, in the direction of standardizing the parts of cars which are liable to become defective while the car is away from home; the object being that each railroad may carry a stock of standard parts. Much has also been done by this Association in the design and location of safety appliances, and these standards are in very general use by the railroads of the country.

The American Railway Association has established exact dimensions for box cars. These dimensions have not been adopted by all railroads, as the commodities handled in different parts of the country require changes in the dimensions to suit the local conditions.

It is our opinion that as much latitude as possible should be given for improvement in design of all details in connection with railroad construction. Through independent thought and the free use of individual designs and methods, we believe the present high standards have been largely obtained.

OSCAR G. MURRAY, President.

CHICAGO, MILWAUKEE & ST. PAUL RAILWAY CO.

So far as the cost and maintenance of car repairs is concerned a uniform car would do much to relieve the situation. However, we feel that the traffic conditions of the different roads necessarily largely determine the class of cars that would be most economical in its service; for example, cars used largely for handling lumber and grain should be of a larger cubic capacity than cars used on roads that handle a large proportion of mineral products.

So far as steel construction is concerned it is yet far from perfect and a standard car, if made standard in its general construction, would naturally have the effect of stopping progress or improvement in steel construction. We have not yet, in my opinion, reached a condition where this is warranted; more than this, I do not think it would be possible for all the roads to realize equal benefits from the same type of car.

W. J. UNDERWOOD, General Manager.

THE DELAWARE AND HUDSON COMPANY.

It is hardly possible that one box car, one type of coal car, or one kind of flat car can be adopted and used universally. Cars owned by any railroad put in the greater part of their time upon the rails of that railroad and in handling its peculiar type of tonnage, and therefore its cars are designed with a view of getting the most economical results from handling this peculiar kind of business. We find in following this a little farther that for the merchandise shipments of New England, the New England roads will generally build smaller box cars and of less capacity than the grain carrying roads of the West, and that the railroads carrying coal to the South will build a coal car which will return lumber to the North.

In other words, the New England road will build a box car for handling merchandise and the Western road for handling grain, while a road with large furniture or agriculture implement establishments will build a larger box car as to cubical contents, than the grain carrying road, but of less capacity in tons.

I therefore feel that it is proper to always have a considerable diversity in the types of cars.

C. S. SIMS, Second Vice-Pres. and Gen. Man.

THE LONG ISLAND RAILROAD COMPANY.

We are of the opinion that it would be desirable for the American Railway Association, in conjunction with the Master Car Builders' Association, to design standard freight cars of such types and capacities as are best suited for different conditions of service. We think the first move would be to have the car committee of the American Railway Association report to the Association before the question is taken up with the Master Car Builders' Association.

RALPH PETERS, Pres. and Gen. Man.

CHICAGO, BURLINGTON & QUINCY RAILROAD COMPANY.

I do not consider that such work on the part of the Master Car Builders' Association would be desirable. It would be simply like asking a convention of tailors to furnish specifications for a suit of clothes for the average man, and we know, of course, that there is no such thing as an average man. Neither are the freight car requirements the same on different railroads in the United States. It is true that many of the details entering into the construction of freight cars are the same, and are standard to-day on the great majority of the American roads; and so far as it is possible to standardize details which are common, I think such action should be taken and I believe it is being taken at the present time, but I am quite sure, speaking for this company, that we would not feel disposed to accept as our standard car a car which might be designed by a committee of very eminent mechanical men, but without special reference to our service requirements.

D. WILLARD, Second Vice-President.

ST. LOUIS AND SAN FRANCISCO RAILROAD COMPANY.

As all the large systems of the country are endeavoring to adopt standard equipment, I believe that the general adoption by the M. C. B. Association of standard freight cars would be simply an additional step forward.

Freight traffic is shipped in carload lots from one end of the country to the other, and in the event that one standard for each class of freight cars could be adopted, it would reduce the cost of repairs of home cars on foreign lines, and as you state, increase their efficiency.

There is certainly no important reason why the Master Car Builders' Association should not design standard freight equipment; on the contrary, there are good reasons why it should be done.

A. DOUGLAS, Fourth Vice-Pres. and Gen. Aud.

THE CHICAGO, ROCK ISLAND & PACIFIC RAILWAY CO.

I agree that it is desirable, but up to the present time it has not been possible to secure the co-operation of the principal roads.

Several years ago the American Railway Association decided on 38 ft. as the desirable standard for the length of box cars; also on standard width and height, but only a few of the roads accepted this standard and they have gone their several ways in the construction of cars of different sizes.

There could certainly be no objection to having the Master Car Builders agree on a design for cars of different types, with the hope that their recommendation might become standard on a large number of roads.

H. U. MUDGE, Second Vice-President.

ATLANTIC COAST LINE RAILROAD COMPANY.

It would, of course, be a matter of great convenience, and would facilitate the making of repairs, if all cars of each class were alike, but the requirements are so varied, and the ideas of mechanical officers so different as to the best type and design of car, that I am afraid it would be a very difficult task to arrive at a standard car.

W. N. ROYALL, General Manager.

——— RAILROAD.

The fact that the box car committee of the American Railway Association has had wide experience in working upon a similar problem makes it important that the advice of that committee should be secured before entering into the broader investigation proposed.

The features that would have to be covered by such a recommendation are many, and involve important operating and traffic conditions as well as the question of designs. It would, therefore, seem advisable, if it is decided to make such an investigation, to have it placed in the hands of the box car committee to report to the Association upon the general dimensions and capacities of the different types of cars, after which the Master Car Builders' Association could be asked to recommend the prominent details of construction adapted to such dimensions and capacities. Such an investigation, if carefully worked out to a conclusion, would be one of great magnitude, as is evidenced by the fact that the box car committee, which was appointed in 1899, spent more than two years in working up its report upon box cars alone.

——— ———, General Manager.

(Established 1832).

AMERICAN ENGINEER AND RAILROAD JOURNAL.

PUBLISHED MONTHLY

BY

R. M. VAN ARSDALE

J. S. BONSALL,
Business Manager.

140 NASSAU STREET, NEW YORK

R. V. WRIGHT, E. A. AVERILL, } Editors.

JUNE, 1908

Subscriptions.—$2.00 *a year for the United States and Canada;* $2.50 *a year to Foreign Countries embraced in the Universal Postal Union. Remit by Express Money Order, Draft or Post Office Order. Subscription for this paper will be received and copies kept for sale by the Post Office News Co., 217 Dearborn St., Chicago, Ill. Damrell & Upham, 283 Washington St., Boston, Mass. Philip Roeder, 307 North Fourth St., St. Louis, Mo. R. S. Davis & Co., 346 Fifth Ave., Pittsburg, Pa. Century News Co., 6 Third St., S. Minneapolis, Minn. W. Dawson & Sons, Ltd., Cannon St., Bream's Buildings, London, E. C., England.*

Advertisements.—*Nothing will be inserted in this journal for pay,* EXCEPT IN THE ADVERTISING PAGES. *The reading pages will contain only such matter as we consider of interest to our readers.*

Contributions.—*Articles relating to Motive Power Department problems, including the design, construction, maintenance and operation of rolling stock, also of shops and roundhouses and their equipment are desired. Also early notices of official changes, and additions of new equipment for the road or the shop, by purchase or construction.*

CONTENTS

THE DRAFTING ROOM.

One of the most complete railroad mechanical department drawing room systems on this continent is that of the Canadian Pacific Railway at Montreal, Canada. Possibly this is due, to some extent, to the fact that the greater part of the new equipment for this large and growing system is manufactured in the company's shops and to the steps which have been taken tending toward a complete standardization of the rolling stock. We are fortunate in being able to present the first part of an article by Mr. Evans, the chief draftsman of the locomotive department, describing the drawing room system in detail. When completed the article will cover not only the methods of making and filing tracings and blue prints, the distribution of blue prints and the handling of specifications, but will go fully into the questions of pattern, forging, and manufactured material records and maintenance regulations; also the best method of handling changes and revisions of designs, recording changes in progress and providing material lists for new equipment.

M. M. & M. C. B. CONSOLIDATION.

There is a growing opinion that the Master Car Builders' and the American Railway Master Mechanics' Associations ought to consolidate. It is the rule of the times to get together. There are no reasons, but sentimental ones, against and many good reasons for such a course. Why not pool these interests, already so closely interwoven, and form one big, strong and influential mechanical railroad organization?

RAILROAD SHOP TOOL ROOMS.

The best trained and equipped army in the world would be seriously handicapped if supplied with poor ammunition. The tool room in the railway shop corresponds to the ammunition for an army. One of the most efficient and best managed railroad shop tool rooms is at the Topeka shops of the Santa Fe. The small tools for the entire system are designed and manufactured there and a tool department, under the direction of the assistant superintendent of motive power, not only has this in charge, but also looks after the supply, use and maintenance of all the small tools and machine tool equipment on the system. Probably no other railroad has given as much care and attention to this subject. The general features of this tool system are considered on page 239 of this issue.

THE RAILROAD AGE GAZETTE.

Beginning with the issue of June 5, the *Railroad Gazette* and *The Railway Age* will be issued as a combined publication under the name of the *Railroad Age Gazette.* The principal offices will be in New York and Chicago, with a branch office in Pittsburgh; the combined force of eleven editors will be distributed between these offices. The *Railroad Gazette* is now in its fifty-third year and the *Railway Age* in its thirty-second year. Both of the papers cover the entire development of railroads along the lines of present-day practice, and the *Railroad Gazette* goes back to the time when the railroads of the United States totaled up to less than 19,000 miles, as against about 226,000 at the present time.

The two papers have been active competitors for the last twenty years, and a great deal of time and money has been spent in overlapping, and in procuring duplicate descriptions of new work, duplicate drawings, etc. The wasteful features of this kind of competition will now be eliminated, and the entire efforts of the combined staff will be put into new work, with the intention of making the best railroad paper that can possibly be made. The *Railroad Gazette* has a thriving branch publication in London, known as the *Railway Gazette,* published each week by a thoroughly competent force of English editors. The English office will be of material assistance to the *Railroad Age Gazette* in the future, as it has been to the *Railroad Gazette* in the past, in keeping American readers abreast of the best foreign practice as well as of the best practice in this country.

There have been too many papers in the general railroad field; this consolidation is a long step in the right direction and this journal extends its best wishes for the success of the new enterprise.

THE APPRENTICESHIP SITUATION.

For a number of years there has been a deep-seated conviction that something was wrong with the railroad apprentice systems. This was brought to a focus by the paper on "The Technical Education of Railroad Employees—The Men of the Fu-

ture," presented by G. M. Basford before the 1905 meeting of the Master Mechanics' Association. Mr. Basford directed attention to the importance of this question and to the need of improved methods in handling apprentices and explained the underlying general principles upon which a successful apprentice system should be based.

At the 1907 convention C. W. Cross and W. B. Russell presented a paper describing in detail the apprenticeship system on the New York Central Lines, which is based on the general principles advocated by Mr. Basford. This paper, like Mr. Basford's, was most enthusiastically received—indeed, was considered by many to be the most important subject considered at the convention.

Since the last convention several of the railroads have taken active steps to establish and improve their apprentice systems. The number of apprentices at the nine shops on the New York Central Lines, which have apprentice schools, has increased considerably and one new school has been established on the Michigan Central at St. Thomas. The Santa Fe, with F. W. Thomas as superintendent of apprentices, has established ten schools, taking care of between 300 and 400 apprentices. Several other roads have taken the matter up, among which may be mentioned the Union Pacific, Southern Railway and the Delaware & Hudson; railroads which previously had apprentice systems in effect have made important improvements and substantial progress.

The committee on apprenticeship for the coming convention, as part of its report, will have a practical exhibit of apprentice training and methods in booth 67 on the pier. This exhibit is being very carefully prepared and will show the development of the apprentice system on several of the roads. The committee is to be congratulated on taking this radical and unique step. It is sure to be a success, especially if some of the members of the committee will be at the exhibit, at stated periods each day, to explain the details and answer questions.

OPERATION OF MALLET LOCOMOTIVES.

A recent test of one of the Mallet articulated compound locomotives on the Erie Railroad, the more general results of which are given on page 212 of this issue, revealed a number of very interesting features peculiar to this type of locomotive. These are fully described in the article and it is the intention here to mention a few of the points noticed in several days' observation of the locomotives in their regular service.

As might be expected, the most impressive feature is the enormous amount of power which is under the control of one engineer and is furnished by one fireman. A closer examination shows that this power is fully under the control of the engineer and that these engines can be handled as easily and as accurately as can much smaller machines. This feature is particularly noticeable in spotting the engines on the turntable, where they are often moved less than 1 in. and can be balanced with the greatest accuracy. When the locomotives were first put into service it was believed that so large a machine was beyond the physical ability of one fireman to develop the power required, but after several months' trial the second man was taken off and at present one fireman is doing the work. Such an arrangement would not be possible if the locomotives were to operate at full power for any great length of time, but under the conditions in which they are now being worked, requiring them to develop approximately three-quarters of their theoretical effort for a distance of about seven miles and a time of about one hour, one man is capable of handling them without any great difficulty. He is necessarily furnished with a good grade of coal, well broken.

The locomotives, at the time of these observations, had been in regular service about six months and a careful examination failed to disclose appreciable flange wear on any of the driving wheels. The tires were somewhat worn on the tread, but not more than would be the case with any heavy freight locomotive. The flexible joints in the receiver pipe showed no leakage and operated with the greatest ease. In fact, these monster locomotives are handled in the yards, through switches and cross-overs, with as much confidence as a six-wheel switch engine. In running through the yards at speeds as high as 15 to 20 miles per hour they take cross-overs with great smoothness and do not seem to have any bad effect on the track. The same feature is noticed when working at full power on very sharp curves, in that there is no binding or straining at any point. Taking everything into consideration, the experience so far would indicate that the articulated feature is a complete success.

In the matter of running repairs, there is, of course, much more to be done on one of these engines than there would be on a simple machine, and no doubt their expense in this regard is comparatively high. But when it is considered that they are doing the work which formerly required the service of three very large consolidation engines it will doubtless be found that the cost of running repairs for this pushing service is reduced by the introduction of these engines. It would naturally be expected that engines of this type would have an expense for running repairs approaching twice that of a heavy simple engine of the consolidation type. Observation in the engine house would lead one to think that it would not exceed this.

The engine crews in general express themselves to be perfectly satisfied with this type of power. The engineers find that the power reversing gear relieves them of much hard labor and are pleased with its operation. The manner in which the locomotives automatically take care of themselves when slipping, a feature which is mentioned in the article on page 216 also relieves the engineers to a considerable extent.

There are, of course, some minor points wherein the crews and management can see an opportunity for improvement, but taken altogether the locomotives can be said to be an entire success.

UNIVERSAL STANDARD FREIGHT CARS.

The communications on this subject, in another part of this issue, indicate that from a standpoint of economy and efficiency it would be advisable to secure a much more extensive standardization of freight car details than exists at present. Undoubtedly important advantages would result from the complete standardization of freight cars. This does not necessarily mean that there should be but one class, or one capacity, for each type of car. For instance, it might be advisable to have three or four or more different classes of box cars, differing in size and capacity, to meet the needs of the various districts in which they are to be used most extensively. However, the greater number of the details of the different types of the same capacity could be standardized and undoubtedly a large number of common standards could be adopted for all classes and capacities of cars.

It is true that several systems have each standardized their equipment to some extent and that the standard cars of such roads differ very greatly from each other in detail; this, of course, would make it more difficult to adopt common standard cars on such roads. It hardly seems necessary, especially with the cars interchanged as generally as they are at present, that four or more roads covering the same territory and operating under similar conditions should each require a radically different design for each type of freight car. Each road is, of course, sure that it has the best car, but can they prove it on a dollar and cents basis? Under present conditions of interchange and accounting it is practically impossible to determine the actual cost of maintaining any one car or class of cars. The cars of each of the several roads may be equally good, although differing greatly in design. On the other hand, they could probably all be improved in certain details by combining the experience of the officers of all the roads. Common standard cars designed in this way would probably be more satisfactory than the cars of any one of the roads, but, even admitting that they were not better, if they were adopted and maintained by the roads interested, a marked advance in efficiency and economy would result.

* * * * * * *

It would be interesting to know what the fads or hobbies of individuals are costing the railroads of this country each year. Doubtless you will say that there can be no progress if the in-

dividual does not work out the problems confronting him in his own way. This may be true to a certain extent, but experience has demonstrated that the combined efforts of several experts is much more valuable than the opinion of the individual. How many worthless devices have been tried and found wanting on your road within the past few years? Is there any need of each device being tested by a number of different roads? Would it not be much better and more economical to have some arrangement whereby the tests could be confined within reasonable limits and without putting the railroads to such a heavy expense to develop different devices, as is allowable under present conditions?

* * * * * * *

Apparently the only way in which complete standardization can be brought about is by following the suggestion made by Mr. Kruttschnitt, *i. e.*, that the initiative in this matter should be taken by the executive heads of some ten or twelve large systems and that these gentlemen issue positive instructions to their car builders to agree on standards and then adopt them. Because of the importance and the great extent of this work it would probably be necessary to place it in the hands of a commission made up of representatives from the different systems. A very careful study would first have to be made by properly qualified experts to determine just what types, capacities and sizes of cars should be adopted as standard in order to best meet the traffic and operating conditions on the different roads. When these have been decided upon the details could be worked out by mechanical experts.

There has been such a rapid advance in the art of car designing during recent years that there should be little difficulty in devising strong and serviceable cars of light and durable construction. The greatest difficulty would be in connection with the steel cars, but different types of these cars have been in service for some considerable time, and with the experience that has thus far been gained it would now seem possible for an intelligent committee to select designs which would give splendid results. The committee might possibly fail in selecting the best possible combination of details, but the advantages of having standard cars would be so great as to many times offset this. There are too many "fads" in steel car design and common sense and good engineering would indicate that some of the so-called good "talking points" of different makes of cars are really weaknesses when it comes to handling the car in the repair yard.

Adopting common standard cars does not mean that progress in design must come to a standstill. As conditions change the designs which might be adopted at the present time would have to be modified, but the modifications could be made so that the larger proportion of the common standards could be retained, even though it was necessary to change the capacity and sizes of the cars. The matter of maintaining the common standards and keeping them up to date should be in the hands of a standing committee, or commission, to whom all new designs and devices should be referred. This committee should be given sufficient power so that such devices as seemed to possess merit could be thoroughly tested out.

* * * * * * *

In connection with the problem of deciding upon common standards, and changing common standards, the following extracts, from a paper on "The Purchasing Department and Common Standards," presented before the New York Railroad Club by W. V. S. Thome, director of purchases of the Harriman Lines, are of interest:

"In numerous conferences, which are held periodically, the chief officials of each department concerned, of the various associated companies, have recommended exactly what many of these standards should be. Decisions have been made after considering the advantages from a mechanical and practical, as well as from a commercial point of view, and after opportunity has been given for argument or suggestions from many experienced and technical men, who have used or manufactured the devices or material in question. Later most of these recommended standards have been favorably passed on by a majority of the general managers of the companies concerned, and when formally approved by the director of maintenance and operation of the associated systems have thus been adopted as common standards for all the associated lines.

"When formally adopted, any article remains a common standard until it has been formally canceled or superseded by another device, which the officials concerned have voted to be preferable, either on account of greater efficiency, safety, economy, simplicity or other good and sufficient reason. This method has been found to work most satisfactorily in practice and without too much red tape to be objectionable."

* * * * * * *

If it was decided to adopt such standards it would be a few years before all of them could be worked out and the improved results due to standardization would probably not be apparent for a number of years, but when they did come they would undoubtedly be very great. Repairs would be facilitated and cars would not be held up on foreign lines awaiting the receipt of proper repair material; very much smaller stocks of repair parts could be carried; car builders could afford to build the cars much more cheaply; purchasing agents, equipped with complete specifications, could buy the repair material to better advantage and get better deliveries; standard material could be manufactured more cheaply in the railroad shops.

BOOK NOTE.

Betterment Briefs. By Henry W. Jacobs, Assistant Superintendent Motive Power, Atchison, Topeka & Santa Fe Railway, Topeka, Kansas. Edition de luxe. 6 x 9 in., 240 pages, 136 illustrations.

About four years ago the Santa Fe, under the direction of J. W. Kendrick, vice-president in charge of maintenance and operation, adopted a general plan of shop betterment. The methods followed were radically different from general railroad shop practice, but were based upon good, sound principles which have been advocated, in other lines of business, by the foremost betterment engineers.

The results have been very gratifying, not only to the workmen and those directly in charge of the shops, but to the *directors* and *stockholders* of the company. Its effects have, however, been much more far-reaching than this—the publicity which has been given to the work has done much to stimulate the wave of railroad shop improvement which has passed over the country during recent years. Many motive power officials, who are apparently not in sympathy with the work on the Santa Fe, will have to admit to themselves, upon careful analysis, that a study of the methods in use there, has stimulated them and helped them to better results.

From time to time, since the beginning of the betterment work on the Santa Fe, articles * have appeared in the technical papers or in the proceedings of different associations describing the progress of the work or considering some of its various phases. "Betterment Briefs" is a collection of a number of articles and papers, prepared by Mr. Jacobs, together with editorial comments which appeared at the time of their publication. Most of the articles appeared in the American Engineer and the *Engineering Magazine*. In addition, a large number of illustrations, not heretofore published, are included, showing various special tools, devices, etc., which have been developed in connection with the betterment work.

The contents, by chapters, is as follows: Commercial tool methods in railroad shops; improved devices for railroad shops; high speed steel in railroad shops; practical advice to college men; organization and efficiency in the railway machine shops, divided into five sections: I, specializing and centralizing the operations and equipment; II, the general aspects of standardization; III, centralization and balance of machine tool equipment on an entire railroad; IV, standardization of the small tool equipment; V, erecting shop economics; the relation between the mechanical and store departments; shop efficiency; the square deal to the railway employee.

The edition de luxe is the finest example of the bookmaker's art ever received by this journal. It is to be sincerely hoped that Mr. Jacobs has a second edition in preparation to meet the demand of all those who are interested in shop or motive power betterment.

* A list of the articles which have appeared in this journal may be found in a foot note in connection with Mr. Epler's article on "Betterment Work in the Car Department," in this issue.

A TABULAR COMPARISON OF NOTABLE EXAMPLES OF RECENT LOCOMOTIVES

ARRANGED WITH RESPECT TO CLASSES AND WEIGHTS

PASSENGER LOCOMOTIVES OF TYPES OTHER THAN THE PACIFIC AND PRAIRIE

TYPE.	ATLANTIC. (4-4-2.)									
Name of road	U. P.	Erie	C. M. & St. P.	P. R. R.	N. Y. N. H. & H.	C. B. & Q.	Har. Lines	C. R. I. & P.	G. W. (Eng.)	P. R. R.
Road number or class	21	537	951	2,760	F1	P3	A-81	1,019	40	2,512
Builder	Baldwin	Amer.	Bald.	Amer.	Amer.	Bald.	Bald.	Amer.	Gt. West.	Soc. Als.
When built	1906	1905	1907	1905	1907	1904	1905	1905	1906	1904
Simple or compound	Comp.	Comp.	Comp.	Comp.	Simple	Comp.	Simple	Simple	Simple	Comp.
Tractive effort, lbs	24,281	23,860	22,200	23,300	24,670	21,400	23,560	24,700	25,036	19,530
Weight, total, lbs	209,000	206,000	204,119	200,500	200,000	196,600	196,000	191,300	166,880	164,000
Weight on drivers, lbs	110,000	115,000	105,966	117,200	105,500	101,200	105,000	107,100	88,704	87,850
Weight on trucks, lbs	53,000	52,000	52,353	52,500	48,000	54,200	45,000	42,400	40,096	41.250
Weight on trailer, lbs	46,000	39,000	45,800	30,000	46,500	41,200	46,000	40,800	38,080	34,900
Weight, tender loaded, lbs	162,200	162,800	130,000	132,500	134,000	120,400	162,200	144,000	89,600	132,500
Wheel base, driving	7' 0"	7' 0"	7' 6"	7' 5"	7' 3"	7' 3"	7' 0"	7' 0"	7' 0"	7' ½"
Wheel base, engine	27' 10"	28' 0"	32' 2"	31' 11"	28' 2"	30' 2"	27' 7"	27' 5½"	27' 9"	28' 6 1/16"
Wheel base, engine and tender	58' 5"	60' 9"	66' 9"	61' 4"	56' 1"	57' 6¾"	58' 2"	57' 2"	53' 6¼"	59' 5"
Diameter of drivers	81"	78"	85"	80"	79"	78"	81"	73"	80½"	80 5/16"
Cylinders, number	4	4	4	4	2	4	2	2	4	4
Cylinders, diameter	16" & 27"	15½ & 26"	15" & 25"	16" & 27"	21"	15" & 25"	20"	21"	14¼"	14.8 & 23⅝"
Cylinders, stroke	28"	26"	28"	26"	26"	26"	28"	26"	26"	25 3/16"
Valve gear, type	Wals.	Steph.		Steph.		Steph.	Steph.	Steph.	Steph.	Wals.
Steam pressure, lbs	200	220	220	205	200	210	200	185	225	227½
Boiler, type	Str.	E. W. T.	W. T.	Belp.	E. W. T.	E. W. T.	Str.	Str.	Belp.	Belp.
Boiler, smallest diameter	70"	70¾"	66"	65⅝"	68"	64"	70"	72"	58¾"	59⅝"
Boiler, height center	113"	111⅜"	114"	109"	110"	108⅛"	113"	108"	98"	106 5/16"
Heating surface, tubes, sq. ft	2475.	3453.6	3008.	2680.2	3041.	3050.5	2475.	2227.6	1988.65	2435.7
Heating surface, firebox, sq. ft	180.	181.1	168.	181.4	204.4	155.5	174.	161.8	154.26	181.1
Heating surface, total, sq. ft	2655.	3634.7	3194.	2861.6	3245.4	3206.	2649.	2389.4	2142.91	2616.8
Heating surface, superheater, sq. ft								338.		
Grate area, sq. ft	49.5	56.5	45.	55.5	53 5	44.1	49.5	44.8	27.07	33.9
Firebox, length	108"	108⅛"	107"	111"	108⅛"	96⅛"	108"	96"	98½"	119⅞"
Firebox, width	66"	75¼"	60⅛"	72"	71¼"	66¼"	66"	67¼"	38½"	40
Fuel, kind	Bit. coal	Bit. coal.	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal
Tubes, number firetube	297	388	268	315	347	264	297	173	250	139*
Tubes, number superheater								54		
Tubes, diameter, firetube	2"	2"	2¼"	2"	2"	2¼"	2"	2"	2"	2 13/16"
Tubes, diameter, superheater								3½"		
Tubes, length	16' 0"	17' 0"	19'	16' 3"	16' 10"	19' 0"	16' 0"	16' 0"	15' 2 5/8"	14' 5¼"
Tender, coal capacity, tons	10	16	10	12½	14	12	10	12		12½
Tender, water capacity, gals	9,000	8,500	7,000	5,500	6,000	6,000	9,000	7,000	3,500	5.500
Weight on drivers ÷ tractive effort	4.53	4.82	4.75	5.	4.27	4.7	4.48	4.2	3.7	3.5
Weight total ÷ tractive effort	8.6	8.63	9.20	8.6	8.10	9.2	8.35	7.8	6.64	8.4
T. E. × diam. drivers ÷ total H. S.	740.	513.	610.	650.	600.	518.8	717.	754.	943.	600.
Total heat. surf. ÷ grate area	53.8	64.3	70.50	51.6	60.50	73.	53.6	53.3	78.8	77.5
Firebox heat. surf. ÷ total H. S. %	6.8	5.	5.30	9.37	6.30	4.85	6.6	6.75	7.2	6.9
Wgt. on drivers ÷ total heat. surf	41.5	31.7	38.10	41.	32.60	31.5	39.6	44.8	41.4	33.6
Wgt. total ÷ total heat. surf	78.9	56.8	64.	70.	61.80	61.3	74.	80.	78.	62.6
Total H. S. ÷ superheating heat. surf.								7.08		
Cylinder volume, cu. ft.	10.2†	8.93†	9.†	10.2†	10.40	8.3†	10.2	10.4	9.6	7.15†
Total heat. surf. ÷ cyl. vol.	262.	408.	355.	280.	311.	387.	260.7	230.	223.	367.
Sup. heat. surf. ÷ cyl. vol.								32.5	69.	
Grate area ÷ cyl. vol.	4.83	6.27	5.	5.42	5.16	5.3	4.85	4.3	2.82	4.72
Reference in THE AMERICAN ENGINEER	1906, p. 308	1905, p. 287	1908, p. 37	1906, p. 73	1907, p. 471	1904, p. 212	1905, p. 154	1905, p. 329	1907, p. 57	1904, p. 203

TYPE.	TEN WHEEL. (4-6-0.)					AMERICAN. (4-4-0)		
Name of road	B. & A.	S. P.	D. L. & W.	N. Y. C.	C. & N. W.	C. R. R. of N. J.	D. L. & W.	L. S. & M. S.
Road number or class	1,916	2,317	1,012	2,099		852	955	Pony
Builder	Amer.	Bald.	Amer.	Amer.	Amer.	Amer.	Amer.	L. S. & M. S.
When built	1908	1907	1905	1905	1907	1905	1905	1906
Simple or compound	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Simple
Tractive effort, lbs	31,000	36,570	35,100	31,000	30,900	23,120	23,710	15,700
Weight, total, lbs	208,000	203,300	201,000	194,500	179,500	161,300	151,200	126,600
Weight on drivers, lbs	158,000	160,000	154,000	148,000	135,500	111,300	100,000	85,100
Weight on trucks, lbs			47,000	46,500	44,000	50,000	51,200	41,500
Weight on trailer, lbs	155,800	43,300						
Weight, tender loaded, lbs		141,366	120,000	143,500	139,500	122,200	110,000	105,200
Wheel base, driving	15' 10"	13' 10"	14' 4"	15' 10"	14' 10"	8' 3"	8' 6"	9' 0"
Wheel base, engine	26' 10½"	25' 10"	25' 6"	26' 10½"	25' 10"	23' 1½"	24' 5"	25' 1¼"
Wheel base, engine and tender	59' 3"	58' ¼"	54' ¼"	59' 2"	57' 9"	49' 2"	51' ⅝"	48' 4¾"
Diameter of drivers	69"	63"	69"	69"	63"	69"	69"	63"
Cylinders, number	2	2	2	2	2	2	2	4
Cylinders, diameter	22"	22"	21½"	22"	21"	19"	20"	12½"
Cylinders, stroke	26"	28"	26"	26"	26"	26"	26"	20"
Valve gear, type			Steph.	Steph.	Wals.	Steph.	Steph.	Wals.
Steam pressure, lbs	200	200	215	200	200	200	185	180
Boiler, type	E. W. T.	W. T.	Str.	W. T.	E. W. T.	W. T.	Str.	W. T.
Boiler, smallest diameter	72⅛"	72"	74⅝"	70⅝"	66⅜"	62¼"	61 3/16"	50"
Boiler, height center	115"	102"	116½"	115"		113"		78"
Heating surface, tubes, sq. ft	3104.5	2788.	3156.3	3124.7	2808.4	1838.1	1947.9	1,326.
Heating surface, firebox, sq. ft	203.3	206.	221.7	202.7	150.8	167.6	190.8	140.
Heating surface, total, sq. ft	3307.8	2994.	3378.	3326.7	2959.2	2005.7	2138.7	1,466.
Heating surface, superheater, sq. ft								
Grate area, sq. ft	54.9	32.1	94.8	54.93	46.27	81.6	87.54	21.
Firebox, length	105⅛"	124"	126⅛"	108⅛"	102⅛"	122⅛"	126 3/16"	96"
Firebox, width	75¼"	37¼"	108¼"	75¼"	65¼"	96¼"	100"	31"
Fuel, kind	Bit. coal	Oil	Anth. coal	Bit. coal	Bit. coal	Anth. coal	Anth. coal	Bit. coal
Tubes, number firetube	400	355	398	400	337	280	280	187
Tubes, number superheater								
Tubes, diameter, firetube	2"	2"	2"	2"	2"	2"	2"	2"
Tubes, diameter, superheater								
Tubes, length	14' 11"	15"	15' 3"	14' 11"	16' 0"	12' 6"	13' 4¼"	13' 6½"
Tender, coal capacity, tons	12	2,940	10	12	10	12	10	10
Tender, water capacity, gals	8,000	7,000	6,000	7,000	7,500	5,000	5,000	4,300
Weight on drivers ÷ tractive effort	5 10	4.37	4.38	4.77	4.38	4.8	4.22	5.4
Weight total ÷ tractive effort	6.70	5.57	5.72	6.27	5.80	6.95	6.4	8.1
T. E. × diam. drivers ÷ total H. S.	617.	770.	717.	647.	655.	800.	765.	670.
Total heat. surf. ÷ grate area	60.20	93.	35.6	60.5	64.	24.7	24.4	69.5
Firebox heat. surf. ÷ total H. S. %	6.15	6.90	6.6	6.1	5.10	8.4	8.9	9.5
Wgt. on drivers ÷ total heat. surf	51.	53.40	45.6	44.5	45.75	55.3	46.8	58.
Wgt. total ÷ total heat. surf	67.	68.	59.8	58.7	60.50	80.5	71.	86.5
Total H. S. ÷ superheating heat. surf.								
Cylinder volume, cu. ft.	11.40	12.30	10.9	11.4	10.4	8.6	9.5	5.7
Total heat. surf. ÷ cyl. vol.	288.	243.	311.	292.	287.	233.	224.	257.
Sup. heat. surf. ÷ cyl. vol.								
Grate area ÷ cyl. vol.	4.8	2.61	8.68	4.8	4.45	9.5	9.2	3.68
Reference in THE AMERICAN ENGINEER		1907, p. 481	1905, p. 407	1906, p. 59	1907, p. 247			1906, p. 293

* Serve tubes. † Equivalent simple cylinders.

A TABULAR COMPARISON OF NOTABLE EXAMPLES OF RECENT LOCOMOTIVES

ARRANGED WITH RESPECT TO CLASSES AND WEIGHTS

PASSENGER LOCOMOTIVES OF THE PACIFIC (4-6-2) AND PRAIRIE (2-6-2) TYPES

TYPE	PACIFIC												
Name of road	P. R. R.	N. Y. C.	N. P.	A. T. & S. F.	Erie	R. F. & P.	B. & O.	N. Y., N.H. & H.	C. B. & Q.	Mex. Nat.	A.T. & S.F.	Har. lines	A.T. & S.F.
Road number or class	K 28	3565	2,175	1290	2,511	84	P	I 1	S1	420	1,251	p.141	1800
Builder	Amer.	Amer.	Amer.	Bald.	Amer.	Bald.	Amer.	Both		Bald.	Bald.	Bald.	Bald.
When built	1907	1908	1906	1908	1905	1907	1906	1907	1906	1907	1905	1905	1906
Simple or compound	Simple	Simple	Comp.	Simple	Simple	Simple	Simple	Simple	Simple	Comp.	Comp.	Simple	Comp.
Tractive effort, lbs	30,700	29,200	30,340	32,600	30,300	31.100	35,020	31,560	31,100	35,066	32,800	29,920	37,800
Weight, total, lbs	272,500	266,000	240,000	232,750	230,500	230,800	229,000	229,500	228,000	227,340	226,700	222,000	248,200
Weight on drivers, lbs	183,900	171,500	157,000	140,400	149,000	143,750	150,500	142,500	150,000	147,040	151,900	141,000	174,700
Weight on trucks, lbs			53,000	54,950	41,000	46,850	40,500	46.500	42,000		35,800	37,000	31,300
Weight on trailer, lbs			30,000	37,400	40,500	40,200	38,500	41.000	36,000		39,000	44,000	42,200
Weight, tender loaded, lbs	143,800	164,000	141,350	165,200	163,000	350,000	147,000	134,000	148,200	142,660		162,200	175,000
Wheel base, driving	13′ 10″	14′	12′ 0″	12′ 8″	13′ 0″	12′ 10″	13′ 2″	13′ 1″	12′ 10″	12′ 0″	13′ 8″	13′ 4″	13′ 8″
Wheel base, engine	35′ 2½″	36′ 6″	33′ 5″	34′ 4¾″	33′ 8″	32′ 8″	34′ 3½″	33′ 5½″	32′ 9″	33′ 11″	34′ 0″	33′ 4″	33′ 9″
Wheel base, engine and tender	67′ ¾″	67′ 11″	62′ 10″	65′ 2″	65′ 1″	61′ 11½″	66′ 3¾″	61′ 2″	64′ 3¾″	62′ 11″	66′ 1½″	63′ 10½″	65′ 0″
Diameter of drivers	80″	79″	69″	73″	74″	73″	74″	73″	74″	67″	73″	77″	69″
Cylinders, number	2	2	4	2	2	2	2	2	2	4	4	2	4
Cylinders, diameter	24″	22″	16½″ & 27½″	25″	22½″	22″	22″	22″	22″	17″ & 28″	17″ & 28″	22″	17½″ & 29″
Cylinders, stroke	26″	28″	26″	28″	26″	28″	28″	28″	28″	28″	28″	28″	28″
Valve gear, type	Wals.	Wals.	Wals.		Steph.		Steph.		Steph.	Steph.	Steph.	Steph.	Wals.
Steam pressure, lbs	205	200	220	160	200	200	225	200	200	220	220	200	225
Boiler, type	Str.	Conical	E. W. T.	Str.	Str.	Str.	Str.	Str.	W. T.	W. T.	W. T.	Str.	E. W. T.
Boiler, smallest diameter	78″	72″	72¼″	72″	74⅝″	74″	72″	70″	70″	70″	70″	70″	76″
Boiler, height center	119″		115″	114¼″	113½″	112½″	112″	110″	109¾″	109″		113″	115″
Heating surface, tubes, sq. ft	4243	3981.6	2667.	3202	3131.	3917.	3,234.6	3743.	3,732.	3,527.	3,402.2	2,874.	3,803.
Heating surface, firebox, sq. ft	205	228.3	241.8	190	195.	190.	179.4	204.4	200.	186.	192.8	174.	217.
Heating surface, total, sq. ft	4448	4209.9	2908.8	3392	3326.	4107.	3,414.	3947.4	3,932.	3,713.	3,595.	3,048.	4020.
Heating surface, superheater, sq. ft					763.								
Grate area, sq. ft	61.86	56.5	43.5	49.5	56.5	49′ 5″	56.24	53.5	54.	52.1	53.	49.5	53.8
Firebox, length	111″	108⅛″	96″	107⅞″	108⅛″	108″	108⅛″	108⅛″	108⅛″	113½″	108″	108″	107 1/16″
Firebox, width	80¼″	75¼″	65¼″	66″	75¼″	66″	75¼″	71¼″	72¼″	66¼″	71¼″	66″	71¼″
Fuel, kind	Bit. Coal	Bit. Coal	Bit. Coal.	Oil	Bit. Coal	Bit. Coal	Bit. coal	Bit. Coal	Bit. coal.	Bit. coal	Oil	Bit. coal	Bit. Coal
Tubes, number firetube	343	382	306	273	195	318	276	310	303	301	290	245	342
Tubes, number superheater					32								
Tubes, diameter, firetube	2¼″	2″	2″	2¼″	2¼″	2¼″	2¼″	2¼″	2¼″	2¼″	2¼″	2¼″	2¼″
Tubes, diameter superheater					5″								
Tubes, length	21′	20′	16′ 9″	20′	20′ 0″	21′	20′ 0″	20′ 6″	21′ 0″	20′ 0″	20′ 0″	20′ 0″	18′ 10 5/16″
Tender, coal capacity, tons	11	14	12	33,009	16	12	15	14	13	12	3,300	12	14
Tender, water capacity, gals	7000	8000	7,000	8,500	8,500	6,000	7,000	6,000	8,000	7,500	8,500	9,000	9,000
Weight on drivers ÷ tractive effort	6.00	5.84	5.2	4.33	4.95	4.62	4.3	4.5	4.8	4.2	4.6	4.7	4.6
Weight, total ÷ tractive effort	8.85	9.11	7.9	7.12	7.7	7.65	6.6	7.25	7.3	6.5	6.9	7.4	6.6
T. E. × diameter drivers ÷ total H S.	550.00	550.00	720.	700.00	669.	560.00	760.	585.00	585.	632.	666.	755.	650.00
Total heating surface ÷ grate area	72.00	74.50	67.	68.50	58.7	82.90	60.5	73.50	71.3	71.2	68.	61.5	74.
Firebox heat. surf. ÷ total H.S. %	4.62	5.35	8.3	5.60	5.85	4.64	5.23	5.20	4.85	5.	5.35	5.70	5.4
Weight on drivers ÷ total heat. surf.	41.50	40.70	53.8	41.50	45.	34.90	44.	36.20	38.	37.4	42.	46.5	43.5
Weight total ÷ total heating surface	61.20	63.10	82.5	68.50	69.5	56.10	66.5	58.20	58.	61.1	63.	73.	62.
Total H.S. ÷ superheating heat. surf.					4.35								
Cylinder volume, cubic feet	13.60	12.32	9.9*	16.00	12.	12.30	12.3	12.30	12.3	11.6*	11.6*	12.3	12.1*
Total heating surface ÷ cyl. volume	326.00	341.00	294.	212.00	277.	334.00	278.	321.00	318.	330.	3.10	248.	334.
Superheating heating surf. ÷ cyl. vol.					63.5								
Grate area ÷ cylinder volume	4.55	4.58	4.3	3.10	4.7	4.03	4.56	4.20	4.39	4.54	4.55	4.	4.43
Reference in THE AMERICAN ENGINEER	1907 p. 267	1908 p. 164	1906 p. 411	1908 p. 112	1905 p. 172	1907 p. 407	1906 p. 257	1907 p. 431	1906 p. 300	1907 p. 70	1905 p. 451	1905 p. 154	1906 p. 435

TYPE	PRAIRIE				
Name of road	L.S. & M.S.	C. B. & Q.	N. P.	G. N.	Wabash†
Road number or class	4,724	R5	2,378	J1	G1
Builder	Amer.	Amer.	Amer.	Bald.	Both
When built	1906	1906	1906	1906	1907
Simple or compound	Simple	Simple	Simple	Simple	Simple
Tractive effort, lbs	27,850	35,060	33,300	37,560	34,558
Weight, total, lbs	233,000	216,000	209,500	209,000	205,900
Weight on drivers, lbs	165,200	152,000	152,000	151,000	150,500
Weight on trucks, lbs	26,000	25,600		21,000	21,900
Weight on trailer, lbs	41,800	38,400		37,000	
Weight, tender loaded, lbs	159,900	148,200	139,500	151,000	153,000
Wheel base, driving	14′ 0″	13′ 4½″	11′ 0″	13′ 0″	13′ 4½″
Wheel base, engine	34′ 3″	30′ 8½″	28′ 11″	30′ 9″	30′ 8½″
Wheel base, engine and tender	62′ 5½″	62′ 2¾″	57′ 3½″	63′ 8″	61′ 4¼″
Diameter of drivers	79″	69″	63″	69″	70″
Cylinders, number	2	2	2	2	2
Cylinders, diameter	21½″	22″	21″	22″	22″
Cylinders, stroke	28″	28″	28″	30″	28″
Valve gear, type	Wals.	Steph.	Steph.	Wals.	Steph.
Steam pressure, lbs	200	210	200	210	210
Boiler, type	E. W. T.	W. T.	E. W. T.	Belp.	E. W. T.
Boiler, smallest diameter	70″	70″	72⅛″	72″	70″
Boiler, height center	114″	107⅜″	115″	108″	107⅞″
Heating surface, tubes, sq. ft	3,678.	3,375.	2,105.	3,277.	3370
Heating surface, firebox, sq. ft	227.	200.	235.	210.	190
Heating surface, total, sq. ft	3,905.	3,575.	2,340.	3,487.	3560
Heating surface, superheater, sq. ft					
Grate area, sq. ft	55.	51.	43.5	53.15	54.25
Firebox, length	108⅛″	108⅛″	96″	116″	108⅛″
Firebox, width	73¼″	72¼″	65¼″	66″	72¼″
Fuel, kind	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal
Tubes, number firetube	322	303	306	301	303
Tubes, number superheater					
Tubes, diameter, firetube	2¼″	2¼″	2″	2¼″	2¼″
Tubes, diameter superheater					
Tubes, length	19′ 6″	19′ 0″	13′ 3″	18′ 6″	19′
Tender, coal capacity, tons	15	13	12	13	15
Tender, water capacity, gals	8,000	8,000	7,000	8,000	7,700
Weight on drivers ÷ tractive effort	4.4	4.3	4.6	4.	4.35
Weight, total ÷ tractive effort	8.3	6.2	6.3	5.6	5.95
T. E. × diameter drivers ÷ total H S.	565.	677.	900.	746.	680.00
Total heating surface ÷ grate area	71.	64.8	53.8	65.	65.70
Firebox heat. surf. ÷ total H.S. %	5.8	5.34	10.1	6.0	5.32
Weight on drivers ÷ total heat. surf.	42.	42.5	65.	43.5	42.20
Weight total ÷ total heating surface	61.	60.7	89.5	60.	58.00
Total H.S. ÷ superheating heat. surf.					
Cylinder volume, cubic feet	11.7	12.3	11.2	13.2	12.32
Total heating surface ÷ cyl. volume	335.	290.	209.	265.	290.00
Superheating heating surf. ÷ cyl. vol.					
Grate area ÷ cylinder volume	4.68	4.46	3.89	4.03	4.41
Reference in THE AMERICAN ENGINEER	1906 p. 204	1906 p. 300	1906 p. 392	1906 p.365	1908 p. 31

* Equal equivalent simple cylinders. † Designed for fast freight service.

A TABULAR COMPARISON OF NOTABLE EXAMPLES OF RECENT LOCOMOTIVES

ARRANGED WITH RESPECT TO CLASSES AND WEIGHTS

FREIGHT LOCOMOTIVES OF OTHER TYPES THAN THE CONSOLIDATION

TYPE	0440 MALLET				SANTA FE 2-10-2		DECAPOD 2-10-0	MIKADO 2-8-2	
Name of road	Erie	G. N.	B. & O.	G. N.*	P. S. & N.*	A. T. & S. F.	B. R. & P.*	N. P.	N. P.
Road number or class	2,600	L-1	2,400	....	98	900	....	W.	1,608
Builder	Amer.	Bald.	Amer.	Bald.	Bald.	Bald.	Amer.	Amer.	Amer.
When built	1907	1906	1904	1907	1907	1903	1907	1905	1906
Simple or compound	Comp.	Comp.	Comp.	Comp.	Simple	Tan. comp.	Simple	Tan. comp.	Simple
Tractive effort, lbs	94,800	71,600	70,000	57,760	60,000	62,800	55,350	45,000	46,630
Weight, total, lbs	410,000	355,000	334,500	288 000	288,000	287,240	275,000	271,000	261,000
Weight on drivers, lbs	410,000	316,000	334,500	250,000	235,000	234,580	248,000	207,000	205,000
Weight on trucks, lbs	....	19,000	....	18,000	....	23,420	....	30 300	26,000
Weight on trailer, lbs	....	20,000	....	20,000	....	29,240	....	33,700	30,000
Weight, tender loaded, lbs	167,700	148,000	143,000	152,000	162,000	158,500	162,000	148,500	177,800
Wheel base, driving	14′ 3″	10′ 0″	....	9′ 10″	19′ 9″	19′ 9″	19′ 0″	16′ 6″	16′ 6″
Wheel base, engine	39′ 2″	44′ 10″	30′ 8″	43′ 7″	35′ 11″	35′ 11″	28′ 4″	34′ 9″	34′ 9″
Wheel base, engine and tender	70′ 5½″	73′ 2¼″	64′ 7″	72′ 0¼″	67′ 4½″	66′ 0″	65′ 3½″	63′ 1″	63′ 1″
Diameter of drivers	51″	55″	56″	55″	57″	57″	52″	63″	63″
Cylinders, number	4	4	4	4	2	4	2	4	2
Cylinders, diameter	25″ & 39″	21½ & 33″	20″ & 32″	20″ & 31′	28″	19″ & 32″	24″	19″ & 30″	24″
Cylinders, stroke	28″	32″	32″	30″	32″	32″	28″	30″	30″
Valve gear, type	Wals.	Wals.	Wals.	Wals.	Wals.	Steph.	Wals.	Steph.	Wals.
Steam pressure, lbs	215	200	235	210	160	225	210	200	200
Boiler, type	Str.	Belp.	Str.	Belp.	E. W. T.	W. T.	Conical.	E. W. T.	E. W. T.
Boiler, smallest diameter	84″	84″	84″	72″	78¾″	78¾″	80″	75¾″	75¾″
Boiler, height center	120″	120″	120″	116″	118″	118″	116″	118″	118″
Heating surface, tubes, sq. ft.	4.971.5	5,473	5.380	3,708	4,586	4.587	3,280	3,819	3,192
Heating surface, firebox, sq. ft.	343.2	230	220	198	210	209	255.5	209	245 †
Heating surface, total, sq. ft.	5,313.7	5,703	5.600	3,906	4,796	4.796	3.535.5	4,028	3,437
Heating surface, superheater, sq. ft.	....	....	....	....	762	....	....	....	....
Grate area, sq. ft.	100	78	72.2	53.4	58.5	58.5	55.5	43.5	43.5
Firebox, length	126⅛″	117″	108⅛″	116⅛″	108″	108″	108″	96″	96″
Firebox, width	114¼″	96″	96¼″	66¼″	78″	78″	73¾″	65¼″	65¼″
Fuel, kind	Bit coal.	Bit. Coal.	Bit. Coal	Bit. Coal	Bit. Coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal
Tubes, number firetube	404	441	436	301	391	391	404	374	372
Tubes, number superheater	....	....	....	....	....	....	....	....	....
Tubes, diameter, firetube	2¼″	2¼″	2¼″	2¼″	2¼″	2¼″	2″	2″	2″
Tubes, diameter, superheater	....	....	....	....	....	....	....	....	....
Tubes, length	21′	21′ 0″	20′ 10¾″	21′ 0″	20′ 0″	20′ 0″	15′ 6″	19′ 6″	16′6″
Tender, coal capacity, tons	16	13	16	13	14	14	14	12	12
Tender, water capacity, gals	8,500	8,000	7,000	8,000	8,500	8.500	9,000	8,000	10,000
Weight on drivers ÷ tractive effort	4.32	4.4	4.75	4.34	3.91	3.75	4.47	4.6	4.38
Weight, total ÷ tractive effort	4.32	4.95	4.75	5.00	4.8	4.56	5.12	6.0	5.6
T. E. × diam. drivers ÷ total H. S.	910.00	690.	700.	813.	712.	747.	812.	705.	855.
Total heating surface ÷ grate area	53.14	73.	77.3	73.	81.8	81.8	63.3	92.5	78.8
Firebox heat. surf. ÷ total H. S., %	6.46	4.13	3.92	5.05	4.38	4.34	7.2	5.18	7.12
Weight on drivers ÷ total heat. surf.	76.90	55.2	59.5	63.9	49.	48.8	70.1	51.1	59.6
Weight total ÷ total heating surface	76.90	62.	59.5	73.8	60.	59.8	80.3	66.9	75.5
Total H.S. ÷ superheating heat. surf.	....	....	....	....	6.3	....	....	....	....
Cylinder volume, cubic feet	24.00	20.75	19.	17.1	22.82	17.9	14.6	15.8	15.8
Total heating surface ÷ cylinder vol.	222.00	275.	295.	229.	210.	268.	243.	255.	218.
Superheating heating surf. ÷ cyl. vol.	....	....	....	....	33.4	....	....	....	....
Grate area ÷ cylinder volume	4.70	3.75	3.85	3.14	2.57	3.28	3.81	2.75	2.76
Reference in THE AMERICAN ENGINEER	1907 p. 341	1906 p. 371	1904 p. 237, 262	1907 p. 213	1907 p. 88	'03 p. 372, 398 1904 p. 176	1907 p. 133	1905 p. 367	1906 p. 392

TYPE	12-WH'L 4-8-0	10-WHEEL 4-6-0			0-10-0	0-8-0	0-6-0		
Name of road	N. & W.	T. & P.	C. & E. I.	C. P. R.	L.S. & M.S.	C. & O.	P. & L. E.	P. R. R.	B. & O.
Road number or class	N1	375	289	D-10	M.	8	253	B-6	D-23
Builder	Both	Amer.	Bald.	C. P. R.	Amer.	Amer.	Amer.	P. R. R.	Amer.
When built	1907	1907-8	1905	1905-6	1905	1903	1906	1904	1906
Simple or compound	Simple	Simple	Bal. comp.	Simple	Simple	Simple	Simple	Simple	Simple
Tractive effort, lbs	40,163	38,400	31,000	33,300	55,300	41.000	44.100	36.100	29.740
Weight, total, lbs	200,000	197,000	191,060	190,000	270,000	171,175	178,200	170,000	161,080
Weight on drivers, lbs	168,000	165,000	145.260	141,000	270,000	171,175	178,200	170,000	161,080
Weight on trucks, lbs	32,000	32,000	45,800	49,000	....	....	....	....	....
Weight on trailer, lbs	....	....	....	....	....	....	....	....	....
Weight, tender loaded, lbs	116,600	132,867	120,000	123,700	....	121,160	121,300	132,500	85,000
Wheel base, driving	15′ 6″	14′ 10″	13′ 6″	14′ 10″	19′ 0″	13′ 7½″	12′ 0″	11′ 6″	11′ 0″
Wheel base, engine	26′ 5″	26′ 4″	27′ 7″	26′ 1″	19′ 0″	13′ 7½″	12′ 0″	11′ 6″	11′ 0″
Wheel base, engine and tender	53′ 7″	55′ 9¼″	55′ 8″	54′ 6¾″	54′ 5½″	45′ 8″	46′ 2¼″	48′ 3¾″	40′ 9½″
Diameter of drivers	56″	63″	62″	63″	52″	51″	50″	56″	52″
Cylinders, number	2	2	4	2	2	2	2	2	2
Cylinders, diameter	21″	22″	15½″ & 26″	21″	24″	21″	21″	22″	19″
Cylinders, stroke	30″	28″	26	28″	28″	28″	30″	24″	28″
Valve gear, type	Wals.	Wals. ‡	Steph.	Steph.	Wals.	Steph.	Steph.	Steph.	Steph.
Steam pressure, lbs	200	210	225	200	210	200	200	205	180
Boiler, type	W. T.	E. W. T.	W. T.	E. W. T.	W. T.	W. T.	Str.	Belp.	Wooten
Boiler, smallest diameter	70″	70⅛″	64″	70⅜″	80 1/16″	67″	80″	67¾″	70″
Boiler, height center	112″	114⅝″	109″	113½″	115″	112½″	108½″	108″	105″
Heating surface, tubes, sq. ft.	2,605	2,731	2,933.7	2,233	4,422.6	2,573	2,906	2,343.	1,476.67
Heating surface, firebox, sq. ft.	173	200	160.7	180	197.	164	206	152.1	172.84
Heating surface, total, sq. ft.	2,778	2,931	3,094.4	2,413	4.619.6	2.737	3,112	2,495.1	1,649.5
Heating surface, superheater, sq. ft.	....	....	....	378	....	....	....	....	....
Grate area, sq. ft.	45	46.3	46.69	49.5	55.4	38.8	33.3	41.25	73.3
Firebox, length	99⅓″	99″	101⅞″	102⅛″	108⅛″	80″	120″	90″	110″
Firebox, width	64½″	67¼″	66″	69⅞″	73¼″	70″	40″	66″	96″
Fuel, kind	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Anth. coal
Tubes, number firetube	242	326	278	266	447	351	430	3.25	220
Tubes, number superheater	....	....	....	22	....	....	....	....	....
Tubes, diameter, firetube	2¼″	2″	2¼″	2″	2″	2″	2″	2″	2¼″
Tubes, diameter, superheater	....	....	....	5″	....	....	....	....	....
Tubes, length	18′ 4⅞″	16″	18′ 0″	14′ 2⅞″	19′ 0″	14′ 0″	13′ 0″	13′ 10¾″	11′ 6″
Tender, coal capacity, tons	10	12	12	10	12	7	10	11	6
Tender, water capacity, gals	6,000	6.500	6,000	5,000	8,000	6,000	7,000	5,500	4,000
Weight on drivers ÷ tractive effort	4.20	4.30	4.67	4.24	4.86	4.15	4.04	4.7	5.4
Weight, total ÷ tractive effort	4.98	5.13	6.15	5.7	4.86	4.15	4.04	4.7	5.4
T. E. × diam. drivers ÷ total H. S.	810.00	825.00	620.	870.	625.	763.	710.	810.	940.
Total heating surface ÷ grate area	61.60	63.50	66.	48.6	83.	70.5	94.	60.3	22.5
Firebox heat. surf. ÷ total H. S., %	6.25	6.80	5.18	7.42	4.25	5.98	6.6	6.08	10.5
Weight on drivers ÷ total heat. surf.	60.50	56.00	46.7	58.5	58.3	62.3	57.1	68.	97.3
Weight total ÷ total heating surface	72.00	67.00	61.6	78.5	58.3	62.3	57.1	68.	97.3
Total H.S. ÷ superheating heat. surf.	....	....	....	6.39	....	....	....	....	....
Cylinder volume, cubic feet	12.00	12.30	8.93	11.2	14.7	11.2	12.	10.5	9.2
Total heating surface ÷ cylinder vol.	231.00	236.00	346.	215.	314.	245.	260.	238.	179.
Superheating heating surf. ÷ cyl. vol.	....	....	....	33.8	....	....	....	....	....
Grate area ÷ cylinder volume	3.75	3.78	5.2	4.43	3.78	3.48	2.77	3.95	7.95
Reference in THE AMERICAN ENGINEER	1907 p. 444	1908 p. 77	1905 p. 97	1906 p. 165	1905 p. 330	1904 p. 184	1906 p. 346	1904 p. 384	1906 p. 257

* Builders' weights. † Combustion chamber 3′ long. ‡ 20 Walschaert and 20 Stephenson valve gear.

A TABULAR COMPARISON OF NOTABLE EXAMPLES OF RECENT LOCOMOTIVES

ARRANGED IN ORDER OF TOTAL WEIGHTS

FREIGHT LOCOMOTIVES OF THE CONSOLIDATION OR 2-8-0 TYPE

Name of road	N. Y. S & W.	D. & H.	L. S. & M. S.	L. S. & M. S.	P. R. R.	Wabash	A. T. & S. F.	B. & O.	Har. lines
Road number or class	140	1,011	5,962	G-46	2,762		1,950	2,503	C-187
Builder	Bald.	Amer.	Amer.	Amer.	Amer.	Bald.	Bald.	Amer.	Bald.
When built	1906	1906	1906	1903	1905	1906	1908	1905	1905
Simple or compound	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Simple
Tractive effort, lbs	54,100	49,690	45,677	46,500	45,700	42,600	44,000	41,100	43,299
Weight, total, lbs	260,100	246,500	232,500	230,000	220,000	214,500	212,400	208,500	208,000
Weight on drivers, lbs	232,700	217,500	207,000	203,000	198,000	189,600	183,200	185,900	187,000
Weight on trucks, lbs	27,400	29,000	25,500	27,000	22,000	24,900	29,200	22,600	21,000
Weight, tender loaded, lbs	161,900	152,400	149,600	148,000	140,500		175,200	143,500	135,050
Wheel base, driving	17′ 0″	17′ 0″	17′ 6″	17′ 3″	17′ 6″	15′ 9″	15′ 6″	16′ 8″	15′ 8″
Wheel base, engine	26′ 6″	25′ 11″	26′ 5″	26′ 5″	26′ 5″	24′ 6″	24′ 6″	25′ 7″	24′ 4″
Wheel base, engine and tender	60′ 10″	57′ 7½″	60′ 9½″	57′ 9¾″	60′ 3¾″	57′ 10½″	58′ 5″	59′ 8¼″	55′ 11¾″
Diameter of drivers	63″	57″	63″	58″	63″	58″	57″	60″	57″
Cylinders, number	2	2	2	2	2	2	2	2	2
Cylinders, diameter and stroke	28″ × 32′	23″ × 30″	23″ × 32″	23″ × 30″	23″ × 32″	22″ × 30″	24″ × 32″	22″ × 30″	22″ × 30′
Valve gear, type	Wals.	Wals.	Wals.	Steph.	Steph.	Steph.	Wals.	Steph.	Steph.
Steam pressure, lbs	160	210	200	200	200	200	160	205	200
Boiler, type	Str.	Wooten	Rad. stay	W. T.	Str.	W. T.	Str.	Str.	Str.
Boiler, smallest diameter	84″	83¾″	81⅝″	80″	80″	77″	78¾″	74′ 5″	80″
Boiler, height center	120″	113″	118¾″	119½″	117″		114″	118″	114″
Heating surface, tubes, sq. ft	3,931	3,716	3492.18	3,725	3,600	3,053	2,773	2630.1	3,226
Heating surface, firebox, sq. ft	198	329.5	213.05	232	182	192	157	179.3	177
Heating surface, total, sq. ft	4,129	4045.5	3705.23	3,957	3,782	3,245	2,930	2809.4	3,403
Heating surface, superheater, sq. ft	834						600		
Grate area, sq. ft	60.2	99.85	56 5	55	55.4	50.4	47.4	56.24	49.5
Firebox, length	120″	126⅛″	108⅛″	108″	106″	108⅛″	95½″	107⅝″	108″
Firebox, width	72¼″	114″	75¼″	73¼″	75¼″	67¼″	71¼″	75¼″	66″
Fuel, kind	Bit. coal	Anth. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Oil	Bit. coal	Bit. coal
Tubes, number firetube	472	493	446	461	446	360	355	282	413
Tubes, number superheater									
Tubes, diameter, firetube	2″	2″	2″	2″	2″	2¼″	2″	2¼″	2″
Tubes, diameter, superheater									
Tubes, length	16′	14′ 6″	15′	15′ 6⅛″	15′ 4¾″	14′ 6″	14′ 11″	15′ 10″	15′
Tender, coal capacity, tons	15	14	12	16	13½		3,300 G	15	14
Tender, water capacity, gals	9,000	7,800	7,500	7,500	7,000	8,000	8,500	7,000	7,000
Weight on drivers ÷ tractive effort	4.3	4.37	4.5	4.37	4.3	4.44	4.17	4.5	4.3
Weight, total ÷ tractive effort	4.8	4.97	5,0	4.95	4.8	5.	4.75	5.1	4.8
T. E. × diam. drivers ÷ total H. S.	825.	700.	775.	680.	760.	760.	855.	875.	725.
Total heating surface ÷ grate area	68.50	40.5	65.8	72.	68	64.	62.	50.	69.
Firebox heat. surf. ÷ total H. S. %	4.80	8.12	5.75	5.85	4.82	5.9	5.35	6.35	5.2
Weight on drivers ÷ total heat. surf.	56.	53.5	55.8	51.2	52.	58.	62.50	66.	55.
Weight total ÷ total heating surface	63.	60.8	6.25	58.	58.	66.	72.50	74.	61.
Total H. S. ÷ superheating heat. surf.	5.						4.90		
Cylinder volume, cubic feet	22.70	14.4	15.4	14.4	15.4	13.2	16.80	13.2	13.2
Total heating surface ÷ cyl. volume	181.	280.	242.	275.	246.	246.	174.50	213.	259.
Superheating heat. surf. ÷ cyl. vol.	36 8						35.5		
Grate area ÷ cylinder volume	2.65	6.92	3.66	3.8	3.6	3.8	2.82	4.3	3.75
Reference in THE AMERICAN ENGINEER	1907 p. 302	1907 p. 22	1906 p. 263	1903 p. 415, 1904 p. 11	1906 p. 73		1908 p. 112	1906 p. 31	1905 p. 154

Name of road	C. S. N. O. & P.	P. R. R.	C. N. O. & T. P.	C. B & Q.	M. St. P. & S. S. M.	W. P.	C. R. I. & P.	C. P. R.	C of G.
Road number or class		H 6 B	734	D4	445		55D	M4	1,200
Builder	Bald.	Bald.	Both	Amer.	Amer.	Bald.	Bald.	Shops	Bald.
When built	1907	1905	1907	1903	1905	1906	1906	1904-6	1907
Simple or compound	Simple	Simple	Simple	Simple	Comp.	Simple	Simple	Simple	Simple
Tractive effort, lbs	43,300	42,000	44,100	42,500	37,300	44,100	39,600	36,800	34,000
Weight, total, lbs	207,000	204,470	203,600	202,600	201,500	201,330	198,600	186,200	163,390
Weight on drivers, lbs	182,000	181,170	182,000	179,200	174,000	186,330	177,300	163,700	143,290
Weight on trucks, lbs	27,000	23,300	21,600	23,400	27,500	15,000	21,300	22,525	20,100
Weight, tender loaded, lbs	148,000	143,000	146,400	150,200	116,900		140,300	121,400	119,610
Wheel base, driving	16′ 0″	16′ 3″	16′	15 8″	17′ 0″	15′ 8″	17′ 0″	15′ 10″	16′ 0″
Wheel base, engine	24′ 4″	34′ 9″	24′ 3½″	24′ 6″	25′ 11″	24′ 4″	26′ 0″	24′ 4½″	24′ 3½″
Wheel base, engine and tender	56′ 3″	58′ 1½″	56′ 7¼″	69′ 1¼″	55′ 8¼″	57′ 11½″	58′ 0″	53′ 4¼″	53′ 9″
Diameter of drivers	57″	56″	56″	57″	63″	57″	63″	57″	56″
Cylinders, number	2	2	2	2	2	2	2	2	2
Cylinders, diameter and stroke	22″ × 30″	22″ × 28″	22″ × 30″	22″ × 28″	23″ & 35″ × 34″	22″ × 30″	23″ × 30″	21″ × 28	20″ × 28″
Valve gear, type	Wals.	Wals.	Wals.	Steph.	Steph.	Steph.	Wals.	Steph.	Steph.
Steam pressure, lbs	200	205	200	210	210	200	185	200	200
Boiler, type	Str.	Belp.	Str.	Str.	E. W. T.	Str.	E. W. T.	E. W. T.	W. T.
Boiler, smallest diameter	78″	71″	76 11/16″	79½″	67⅜″	80″	74″	69″	61″
Boiler, height center	115½″	108¾″	114⅞″	115″	115″		117″	111½″	105⅜″
Heating surface, tubes, sq. ft	2,939	2675.9	3,051	3511.56	2407.5	2,927	2,427	2,216	2069.3
Heating surface, firebox, sq. ft	183	166.5	175	221.77	158.	214	168	165	140.
Heating surface, total, sq. ft	3,122	2842.4	3,226	3733.33	2565.5	3,141	2,595	2,381	2209.3
Heating surface, superheater, sq. ft					261.4			375	
Grate area, sq. ft	51	49.11	54	54.2	46.8	33.6	50	43	44
Firebox, length	108″	107″	108″	108⅜″	96⅛″	121″	107″	96⅝″	96⅛″
Firebox, width	68″	66″	71¾″	72″	70¼″	40″	67¼″	65¼″	66″
Fuel, kind	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal
Tubes, number firetube	386	373	403	450	224	390	340	244	283
Tubes, number superheater					40			22	
Tubes, diameter, firetube	2″	2″	2″	2″	2″	2″	2″	2″	2″
Tubes, diameter, superheater					3½″			5″	
Tubes, length	14′ 6½″	13′ 8½″	14′ 6½″	15′	15′ 9″	14′ 5″	15′ 6″	14′ 1⅜″	14′ 8″
Tender, coal capacity, tons	12	13½	12½	14	10	14	12	10	8
Tender, water capacity, gals	7,500	7,000	7,500	8,000	6,000	8,000	7,000	5,000	6,000
Weight on drivers ÷ tractive effort	4.2	4.3	4.13	4.2	4.65	4.2	4.5	4.4	4.2
Weight, total ÷ tractive effort	4.76	4.8	4.61	4.8	5.4	4.55	5.	5.1	4.8
T. E. × diam. drivers ÷ total H. S.	790.	830.	768.	650.	830.	800.	965.	800.	860.
Total heating surface ÷ grate area	61.	58.	59.80	69.	55.	93.	52.	55.	50
Firebox heat. surf. ÷ total H. S. %	5.85	5.9	5.42	5.9	6.15	6.8	6.5	6.9	6.3
Weight on drivers ÷ total heat. surf.	58.2	63 5	56.40	48.	48.7	59.5	68.	69.5	65.
Weight total ÷ total heating surface	66.	72.	63.	54.	56.5	64.	77.	78.	74
Total H. S. ÷ superheating heat. surf.					9.85			6.35	
Cylinder volume, cubic feet	13.2	12.4	13.20	12.4	11.4*	13.2	14.4	11.2	10.2
Total heating surface ÷ cyl. volume	236.5	229.	244.06	302.	312.	238.	180.	213.	217.
Superheating heat. surf. ÷ cyl. vol.					23.			33.3	
Grate area ÷ cylinder volume	3.87	3.95	4.10	4.4	4.1	2.55	3.48	3.8	4.3
Reference in THE AMERICAN ENGINEER	1907 p. 194	1906 p. 231	1908 p. 26	1903 p. 48	1905 p. 150		1907 p. 147	1906 p. 165	1907 p. 31

* = Equivalent simple cylinders.

STEEL PASSENGER EQUIPMENT.*

By Charles E. Barba and Marvin Singer.

THE UNDERFRAME.—PART IV.

Synopsis.

Form I.

The total resisting moment of the plate girder is composed of the separate resisting moments of its component members, and not as if the whole were considered a homogeneous unit. Thus this total moment would equal the resisting moments of the two side sills plus that of the two center sills, plus that of the web plate. These can all be reduced to statical moments. The last term involves the moment of inertia from which the area can be separated, leaving it similar in form to the first two.

This has been thus far a preliminary investigation which makes no allowance for the effect of rivet holes in the plate along the transverse supports. Final calculations should be based upon net area. The joints of the ends of adjacent plates at the transverse supports must be examined carefully, so that they are as strong as the plate for the shearing and bending stresses in the web. The shearing stresses have been considered as uniformly distributed, but the moment stresses are not, as they range from 0 at the neutral axis to a maximum at the edge of the web. Hence, having found the moment to be resisted by the web it is required that the riveting be considered as resisting directly as the square of the distance of its center from the neutral axis. This shows the good office fulfilled as far as strength goes by a joint with the riveting most compact near the edge of the plate. If joints, where necessary, are made to come at the transverse supports the lines of riveting will here conserve two functions—one as outlined above and the other to secure the web stiffeners. A plate girder covering the whole floor is somewhat deeper than the economical depth when using 1/8 inch sheets. A sheet of 3/32" plate will give about the lightest construction possible for this type of design with a side sill area of 9 square inches. The plate girder cannot be built as light as the trussed girder, but it is more reliable and affords excellent opportunity for building the floor of the car directly upon it.

The Side Girder.

The transverse supports must have a minimum deflection and deliver their concentrated loads direct to the side girder at a body post, for a minimum bending moment in this girder.

This side girder is composed of the side sill angles as a bottom chord and the belt rail as a top member. In some cases, however, this has been deepened to the side eave. Such construction requires careful investigation as the opportunity for binding of windows is very great. The plates on the sides are required to take up the vertical shears and the diagonal shears set up by the tension and compression. Any window frames set into this plate must be strong enough to sustain these loads and to make up for decreased strength of the web.

The resisting moment for the side girder is of the same form as for the floor girder, except there is no central resisting member.

The value of the stress to allow for the various members may be obtained from the assumption of the maximum deflection permissible under full load and then equating the beam for strength and stiffness and solving for the consequent stress. This stress in no member should be allowed to exceed half the elastic limit of the material. This means that the beam must be designed so that when the side thrust from end shock comes upon the side sill there is reserve strength sufficient to keep it below this figure.

This low stress is necessary, due to the fact that the girder is loaded upon the tension member and the stiffening of the compression member against lateral buckling is a difficult matter. This must be accomplished by means of the posts and carlines which must necessarily be very light for this form, to save weight. The beam lies somewhere between the condition of one with an unbraced top chord and one with it rigidly fastened. The character and cross bending strength of the posts determine to which case it is most nearly analogous.

If it were possible, the flooring should be attached to the compression member and this itself would then prevent the destructive torsional action of the beam. Any construction, therefore, which makes the top chord a tension member for a considerable portion of its length, decreases this tendency. The decrease in the twisting is not directly as the decrease in length of the top compression flange, but as the square of the length. This result was proven by the experiments of Mr. A. E. Guy, wherein he showed that, "the load at which such a beam would buckle sideways is that load which would buckle the same beam if it were placed vertically and thereby converted into a strut."

The character of the curves of moment on the side girder will follow the character of the forms shown in Fig. 3.

Salient Points.

This type of underframe finds its most profitable field of usefulness in service at nominal end shocks and with cars not having side entrances other than at the platforms.

Here the direct resisting members are so weak that they are capable of absorbing but a portion of any fair-sized end shock, and are not suitable to sustain even their own weight without

Errata, Form I.—The weights of trailer cars (70,000) and motor cars (75,000) given on page 83 should read 75,000 and 100,000 respectively.

undue deflection. It is hence necessary that the strains beyond the limits of capability of the center sills be provided for by the balance of the framing. This can be accomplished as follows: For any transverse horizontal movement of the sills a resisting girder can be formed of the floor construction; for any vertical movement of this floor girder a resisting girder can be provided by the construction of the sides of the car.

The side girders are load carriers in a vertical plane and should be capable of taking all the center sill forces transmitted to them by the transverse supports. These loads to be provided for will be the reactions at the points of support of the center sills. These reactions are due to the dead and live lading and the uniform lading equivalent of the end shock. This beam is of the nature of a plate girder of overhanging ends with a uniform dead lading of superstructure and portion of uniform live lading (see p. 12, January issue, Fig. 8), together with the concentrated loading transferred from the center sills.

The floor girder utilizes the side sills and the center sills either by forming a trussed or a plate girder to provide for horizontal bending tendencies of the center sills. The loads coming upon this girder are different for the two types of girders, due to the different character of the reinforcement.

With a stiff floor girder the tendency is toward a downward and not a horizontal deflection, this increases the vertical reactions transferred to the side sills.

The center sills fulfil the conditions of a continuous beam in both vertical and horizontal planes and have, besides the combined flexural stress, a direct stress due to the static end load.

The distinguishing difference between the trussed and plate girder may be noted when the whole floor of the car is considered as a unit taking end shocks. These are imposed directly upon the end of the center sills which in the trussed girder bend locally between the transverse supports. The plate girder prevents this bending and then the center sills are but compression pieces for concentric end shocks.

Following this, the whole floor acts as an end loaded beam, the span of which is the distance betwen truck centers and the remainder overhanging, and would deflect as such. The equivalent side load for end shock is solved similarly to the above cases where the resisting moment is known.

The underframing of the light car just considered for metropolitan and interurban motor car train service, is a direct evolution by various stages from the car which had the buffers and pulling eye fastened upon the platform end sill. Service damage acting as an indicator of points of weakness caused the introduction first of platform sills running back to the bolster, then of a single sill between the bolster and finally a number of longitudinal sills throughout the length of car.

In effect, these sills all carried loads and could be made quite light by the use of truss rods and needle beams. The use of steel showed the possibility of a much stronger side girder and the elimination of the intermediate sills. Removing the truss rods from the center sills the side girder was made to serve the same purpose by the introduction of transverse supports at more frequent intervals than the needle beams. Form I. is thus a direct step in the evolution from wood.

The method of providing for the lading and end shocks of service as found in Form II. is a more radical departure. The field of possible arrangement of underframe members was considered and the study carefully worked out with the fact that the material to be used is much more efficient than wood, and at the same time less elastic.

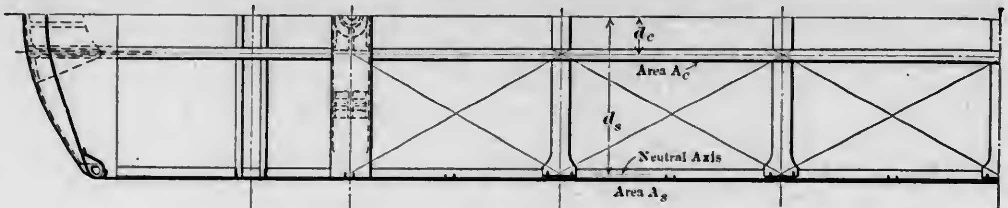


Fig. 1


Fig. 2

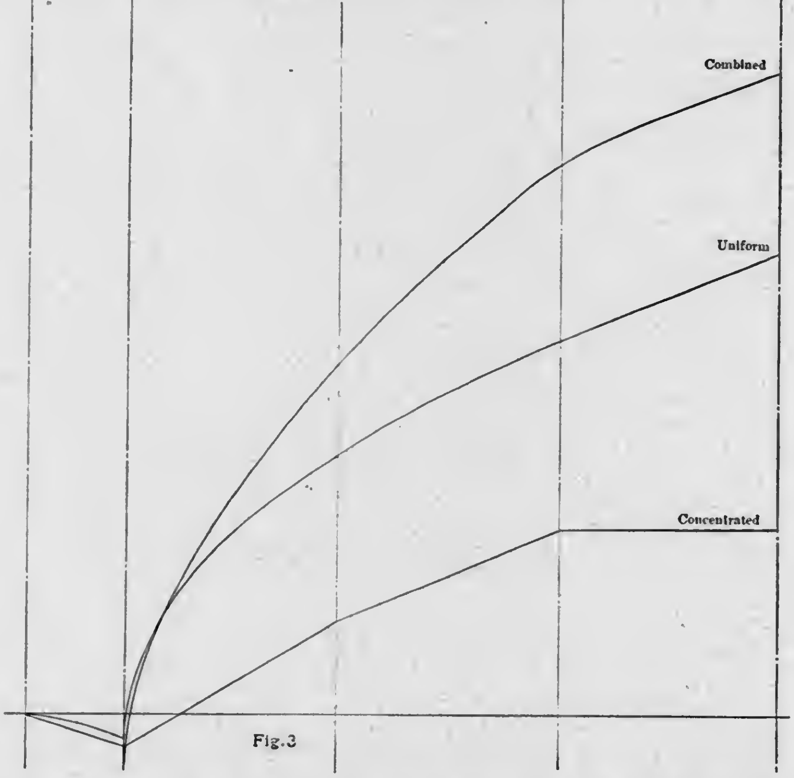


Fig. 3

FORM II.

General Theory.

The general theory upon which this form bases its claims may be concisely stated as, "the production within the center sill members of interior opposing forces whose tendency is to neutralize and leave a minimum of forces of translation or rotation for which provision must be made." Coupled to this is the theory, "that whatever translation does occur the connections between the longitudinal load and shock carriers should not cause this moment to destroy the alignment of the superstructure carrier."

The first of these theories will be found to have been discussed in the first underframe article (December issue); the second will be dealt with here under the effects of side sill supports being upon different levels.

Definition.

Quoting from page 461 (December issue): "The second form is readily known by the absence of any bolster. This is its distinguishing characteristic. In this case the static lading is all transferred at various intermediate points to the center sills which in turn put it directly upon the center plates riveted to them. This type presupposes a strong center sill and may make use of a weaker side girder."

Inquiries upon the subject lead us to believe that but one railroad is using this form and that the various car companies are

building these cars but for the Pennsylvania Lines. The size of the order (200 cars) now being completed and the money represented by such an order are indisputable proof of the belief in its distinguishing features. In addition to this order is the one now building for the Long Island Railroad of 50 coaches of the same form of underframe for suburban steam service and to be ultimately used for multiple unit control. This underframe is shown in Fig. 4.

The underframes as represented in these two orders give every form that is needed for present steam operation with considerations for electricity as noted in our previous articles.

FIELD OF USEFULNESS.

Service.—For trunk line operation using steam or electric locomotive propulsion either in accommodation or express service, this underframe is best adapted. Also for suburban service where the liability of contact with the strong steel freight or express trains is probable.

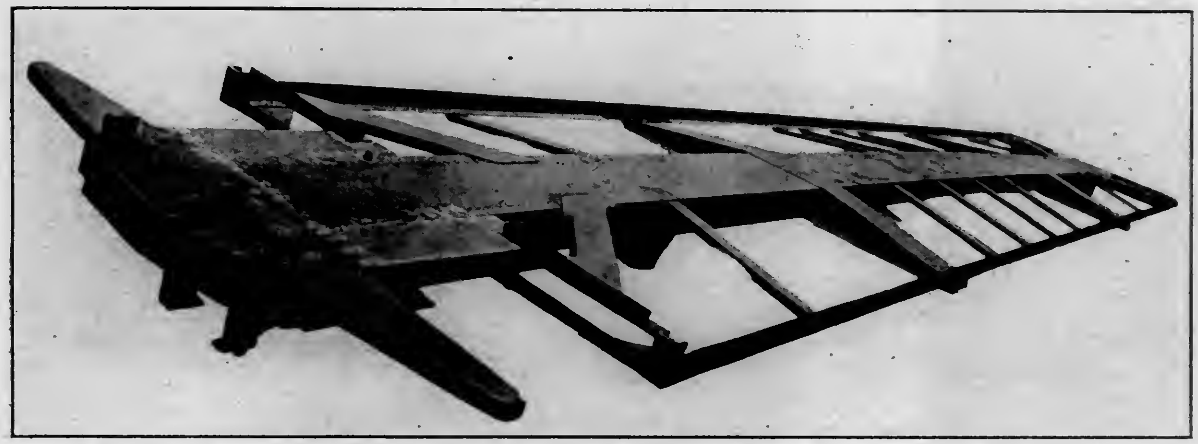


FIG. 4.—UNDERFRAME OF STEEL SUBURBAN CARS FOR THE LONG ISLAND RAILROAD.

The only service for which it cannot be said to be the best form is that for separate car running and the service for which Form I. is adapted, and even this conclusion is open for argument.

Types of Cars.—The variety of cars lending themselves to design upon this underframe is a range of all the types now being built except possibly the side entrance car with a central door—all other arrangements of side doors can be used and make use of its economical principles.

The central entrance side door causes trouble with the second theory, since the deflection at this point is more than at the other points of transverse support connections. The disadvantage of having unequal deflections at the points of superstructure carrying and the harm caused by such difference is dealt with in detail later in this section.

	Length over body end sheets	Truck	Capacity	Weight in pounds*
Passenger Coach	70′ 5¾″	4 wheel	88 pass.	113,500
Postal	71′ 4⅜″	6 "	50,000 pounds	129,000
Baggage Express	60′ 10⅜″	4 "	35,000 pounds	91,000
Passenger Baggage	70′ 0″	6 "	44 pass. 25,000 pounds	130,000
Dining	71′ 11¾″	6 "	30 pass.	140,000
Suburban Passenger	54′ 4″	4 "	72 "	75,000
Suburban Passenger Baggage	54′ 4″	4 "	54 pass. 15,000 pounds	75,000

* Estimated Weights.

Cars of this type now building are given in the above table.

FACTORS OF DESIGN.

The available depth of underframe is limited by two considerations—the height of floor and truck clearance. To clear a standard truck with a center plate of minimum thickness on the bottom of the sills, the bottom would have to be 26¾″ from the rail. An examination of the Pennsylvania cars using their standard steel trucks as illustrated in the AMERICAN ENGINEER in June and July, 1907, shows that by making a special truck with a depressed end truck rail this has been reduced to 29½″. This shows a gain in available space of 7¼″, but contrasted with the wooden equipment this is not as large as it should be, for the reason that the space taken by the bolster running underneath the sills is not considered. This dimension would add to the above for increased possible depth.

The floor and side sill heights should be approximately the same. The detail construction of the flooring will determine whether the tops of the wood and steel center sills are in alignment. The advantage in not using the bolster shows a gain in depth of 11″ for the cars of this type now running. For motor cars the depressed truck rail is not required as the motor case governs the clearance, and this has been stated in the article on Form I. to be 41″.

The steam or electric locomotive service thus permits an additional depth of 11½″ over and above that for multiple control with the same floor conditions. This great available center sill depth is the feature which permits the design to be built according to the economic theory advanced. To resist impact and inertia forces, area in the longitudinal members is necessary. To a greater degree than in any other form of underframe does this type place the area directly in the line of action of the forces of collision.

The American steel manufacturers in opposing the demands of the recent rail specifications of the railroads have brought great pressure to bear upon the question of the destructive influences of the maximum wheel loads at high speeds. The axle lading is then a factor of design whose lessening is a matter of much import. They should not in any case be allowed to increase beyond what is now found. This will be seen to be a very important feature, when it is considered that the intensity of the blow struck upon the rail is a function of the square of the velocity. For this reason it is very probable that a train of steel passenger cars may have a more deleterious effect upon the track than a slower train of heavier wheel loaded freight cars.

This form of underframe requires a truck of special design, if for no other reason than that of the side bearings. The absence of any bolster necessitates the placing of such bearings upon the side sill angles, which gives them a spread wider than is customary. The truck side bearing must come out to meet them and must rest upon a flexible base such as a spring supported swing bolster. This is necessary to secure easy riding and to prevent the frictional resistance to turning of the truck from causing the wheel flanges to override the rail and cause derailment.

The proper spacing of side bearings is a debatable question even in wooden equipment. They now vary from 48″ to 60″. Not alone the spacing, but the character is open to dispute. Friction or frictionless bearings have their able advocates and the same problem with the same divergency of opinion will follow into the steel car. The question bears added weight in the new construction, the flexibility of the car being less and the chattering action being more noticeable.

Weight Limitations.—The theory upon which this design is based makes it a most economical solution to the problem where destructive end shocks must be considered. Economical in so far as weight is concerned as well as material and productive labor. Maintenance and depreciation costs should be very low; repair after an accident will require but minimum effort since the parts sustaining damage are few and these can be designed so that structural shapes could be substituted for original pressed pieces if necessary.

Depreciation costs dwindle because the whole resistance is made compact and of the best form to stand the constant racking of service. The underframe of a 70 ft. car to stand up under the requirements of specifications, should be built to weigh but 25,000 pounds.

Reliability and economy are associated terms. The framing elements afford their intended security when the sum total stresses do not exceed the specified limits and the weight, and hence the sectional area, must be as small as possible and still keep within these limits. The greatest reliability is obtained when the unknown factors of strain are reduced to a minimum and the loads must be taken by the framing as intended. This result is very closely approximated by this type, as the framing permits of but one manner of load acceptance—through the center sills. Hence, knowing the external forces, this underframe is perhaps the nearest approach to engineering exactitude of any.

For the progress of the art it is well that the introduction of steel equipment should oppose adverse conditions as far as competition with wooden equipment is concerned. The future may produce a car which makes of the whole platform a "concussion buffer—*i. e.*, the car between body end sheets will be formed as an exceeding strong longitudinal and vertical unit and the platform designed so as to have a crippling strength weaker than the main car framing. The idea is to have the platforms separate from the car framing and depend upon the ultimate resilience of the platform in crushing to absorb a large portion of the destructive kinetic energy and thus leave but a portion of it to be absorbed by the elastic resilience of the main framing.

In this connection the platforms must be framed capable of sustaining more than the combined capacities of the buffers and the draft gear. On the other hand, they should not approach the strength of the main body framing so closely as to seriously endanger the crippling of these members simultaneously with the platform itself. The platform then, to conserve the purpose outlined, would occupy a position of strength intermediate between the buffing attachments as a lower limit and the specified stress allowed in the body framing for security. Interchangeability should be a feature of this detail platform. It should be designed so that its attachment to the body of the car would facilitate the exchange of a damaged end by a new one if necessary.

Center Sill Lading.—The strains coming upon the individual members of the framing have been dealt with, in so far as the center sills are concerned, in the article illustrating the graphical analysis in the January issue. This article in general assumed any number of transverse supports, showing one (P_4) in the mid region. The most economical underframe would omit this unless the superstructure arrangement required it, and the curves would be altered accordingly. The center sills are then acting under maximum strain as a side loaded column—side loaded both uniform and concentrated. The center sills, being wider than deep, afford greatest resistance to bending in the horizontal plane and leave the transverse supports for the side girder in the condition of double cantilevers. The base of these should be large to afford sufficient attachment at the center sills and side sills for preserving their normal perpendicularity and successfully resisting the tendency of inertia forces from carrying the superstructure beyond the underframe.

In this connection the use of diagonal end struts to carry body corner blows to the center sills should be given consideration.

The ties between the side and center sills other than the cantilevers should be light and not capable of vertical load transference. This would defeat the purpose of the design.

Between supports the two sets of longitudinal sills (side and center) should be capable of independent deflection.

The elimination of auxiliary draft sills is a noticeable feature of the platform end of this underframe. The eccentricity of resultant end shock action can be reduced to zero if desired, but this does not secure an opposition of bending moments at the center of the car as is very desirable and can only be obtained when the resultant is below the neutral axis.

Another region of great stress activity is over the center plate and additional cover plates may be required to provide for it at this point.

Vertical Superstructure Movement.—The value of preserving the same vertical deflection of the points of supports of the side sills is most prominently illustrated by the following considerations:

The side girder is in the condition of a continuous beam of three spans and four supports; the general formula

$$M_n l_n + 2M_{n+1}(l_n + l_{n+1}) + M_{n+2} l_{n+2} = \frac{W_n}{4} l^3_n + \frac{W_{n+1}}{4} l^3_{n+1}$$

previously worked out for continuous beams will hold true only for those beams whose supports remain in the same horizontal plane. If such be not the case, the latter term of the equality will

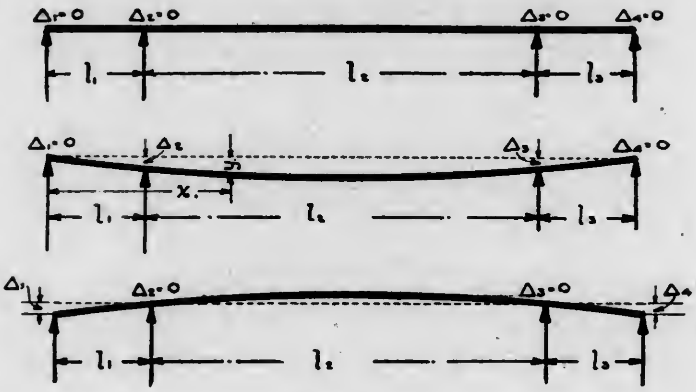


FIG. 5.

be larger than given by an amount depending upon the ratio between the difference in elevation of the ends of a span to its length multiplied by six times the product of the modulus of resistance and elasticity.

These points will remain in the same horizontal plane so long as the transverse supporting cantilevers have a uniform strength or deflection and their points of attachment to the center sills have the same vertical movement due to the deflection of the center sills.

The difference in elevation of the three supports for two spans enters into the problem just as the moments at the three supports enters into the moment formula.

The accompanying illustration (Fig. 5) shows clearly the general cases which may arise in practice from a neglect of the foregoing considerations.

The first diagram shows a continuous beam of three spans of lengths (l_1, l_2, l_3) and four points of support upon the same level. The deflections at the points of support are here zero in each case. To this figure the general formula given above is applicable.

The second diagram shows the mid supports depressed. This condition could happen very easily if the buffing loads do not act to counterbalance the dead and live lading. In this case the relation between x and y is quite different from that used in finding the value of the constant of integration for the tangent equation of the elastic curve from which the given moment relation is deduced. Instead of $y = 0$ for all values of x to the supports $y = 0$ when $x = 0$

$= \triangle_2$ " $x = l_1$

$= \triangle_3$ " $x = l_1 + l_2$

$= 0$ " $x = l_1 + l_2 + l_3$

This diagram shows how the girder may approach the condition of uniformly loaded simple beam and be compelled to assume strains for which it has not been designed. The car will eventually take a permanent downward set in the center and hence appear much weaker than it really is.

The last diagram shows the end sills to have gone down the most. The relations between x and y change in this case as before and are found to be $y = \triangle_1$ when $x = o$

$$= o \quad \text{"} \quad x = l_1$$
$$= o \quad \text{"} \quad x = l_1 + l_2$$
$$= \triangle_3 \quad \text{"} \quad x = l_1 + l_2 + l_3$$

Here the girder approaches to that of a uniformly loaded beam with both ends overhanging. The car is liable to list downward at the end sills. This is the same condition which is noticeable in so many dining cars at the kitchen end. These changed relations alter the formula noted above to read

$$M_n l_n + 2M_{n+1}(l_n + l_{n+1}) + M_{n+2} l_{n+2} = \frac{W_n l^2_n}{4} + \frac{W_{n+1} l^3_{n+1}}{4} - 6EI\left(\frac{\triangle_{n+1} - \triangle_n}{l_n} + \frac{\triangle_{n+1} - \triangle_{n+3}}{l_{n+1}}\right)$$

The effect is really cumulative in that the action tends to increase the deflection of center sills in the locality of the highest support and the operation thus juggles back and forth until a state of equilibrium is reached.

Following the tendency in freight car design of fish bellied pressed steel sills the Pressed Steel Car Company used these upon the Southern Railroad coach (AMERICAN ENGINEER, July, 1906, p. 260). These sills may be used in this form of underframe, but are open to the disadvantage that as the belly deepens the neutral axis lowers, and with a deep sill the conditions as to underhung resultant draft gear may change and the effect sought after in making the buffing oppose the lading moment, be lost. The use of top cover plates will preserve the axis nearer to the upper surface. The bow is helpful in that it permits the spacing of the cantilevers and end sill almost at will with the supporting truck center. This advantage is of much value in the design as it means the elimination of the greatest of the numerous limitations governing superstructure arrangement.

This valuable feature is a result of the change in modulus of resistance of the section. For any beam of whatever character the deflection is a direct function of the load into the cube of the span and the inverse function of the product of the modulus of resistance and moment of inertia. Thus the deflections can be equated for the various points of support and the relation between the values of the required modulus of resistance at the various points deduced. The value of I then governs the deflection and the bellying of the sills will secure the result. With a box girder this is accomplished by the use of additional cover plates and the preservation of the relation between the line of action of the end shock and the neutral axis of the center sill section, is much improved over that for the pressed sills.

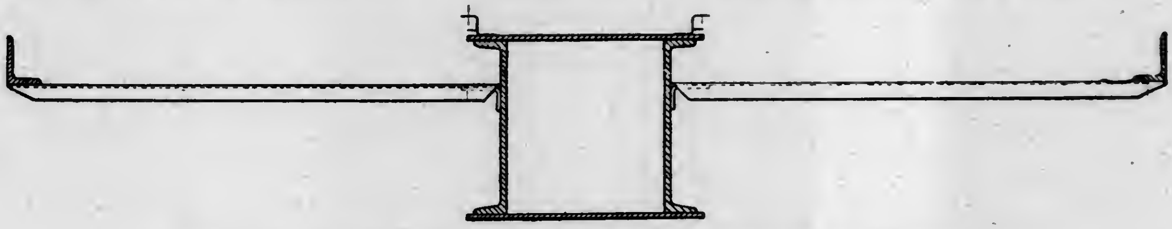


FIG. 6.—SECTION THROUGH FORM II. UNDERFRAME BETWEEN CANTILEVERS.

ANALYTICAL ANALYSIS.

The principles underlying the solution of any case of Form II. were given on pages 15 and 16 (January issue), based upon diagrammatic figure on page 13. These principles are fundamental and apply to all forms. In the table given below, however, the value of $\frac{L}{2}$ has been substituted for X in the column of forces, since this will give the maximum value of M_x.

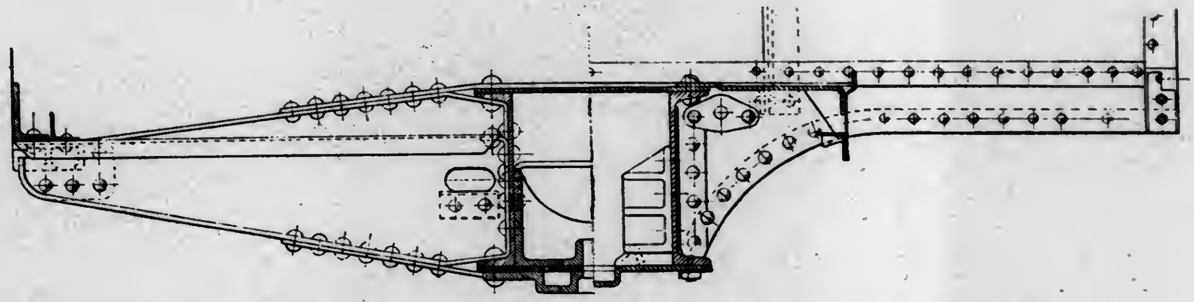


FIG. 7.—SECTION THROUGH FORM II. UNDERFRAME AT CANTILEVER AND AT PLATFORM.

The most economical design of this underframe demands the omission of the central cantilevers and hence the concentrated load coming upon the center sills, as at P_4 in the former case, will not be found in this case. The table, as altered to suit these conditions, which will apply to an underframe of the type shown in Figs. 6, 7 and 8, is shown in Fig. 9.

In substituting values of P_n it must be remembered that in removing P_4 the value of P_3 is increased by the value of d covering what is now 2d + c. (See Fig. 11, page 13.)

The value of w here noted is the uniform side load equiva-

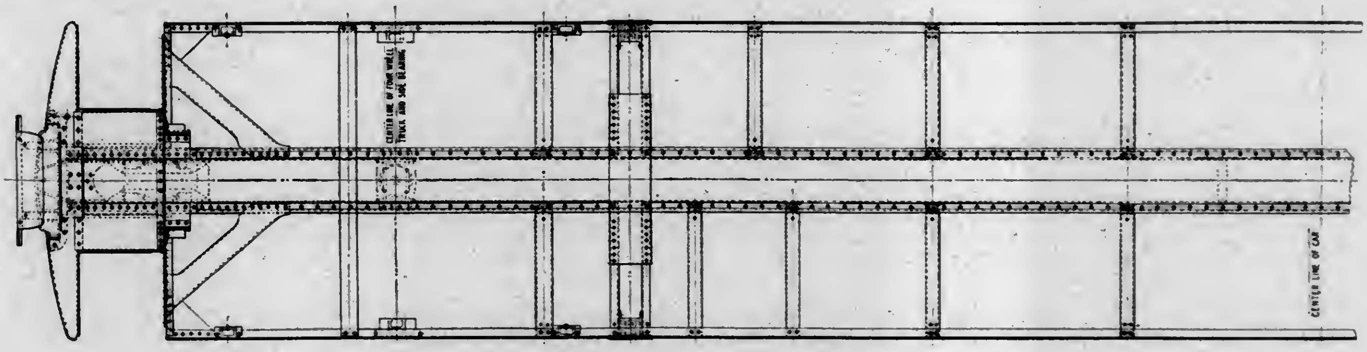


FIG. 8.—PLAN OF FORM II. UNDERFRAME.

lent of the end shock and is found from equating the end moments:

$$150,000\ (J + \Delta') = \frac{W}{2}\left(\frac{L}{2} + a + b\right)^2$$

The one approximation in this analysis is the assumption upon which the values of P are based. These are quite near to being correct without much calculation. To be precise, they are the reactions from the three span continuous side girder. The same remark will hold true in the graphical analysis and the moment curves at the center of the car will be reduced by the elimination of the central loads.

$+\ -$ $\uparrow\downarrow$	Forces in pounds		Arm to section in feet	Bending moment in foot pounds
+	Reaction	$P_1+P_2+P_3+\left(\frac{L}{2}+a+b\right)(550+w)$	x	$P_1x+P_2x+P_3x+(w+550)\left(\frac{L}{2}+a+b\right)x$
—	Platform end sill	P_1	$x+a+b$	$-P_1x-P_1a-P_1b$
—	Body end sill	P_2	$x+b$	$-P_2x-P_2b$
—	Inter-Cantilerer	P_3	$x-c$	$-P_3x+P_3c$
—	Uniform centre sill Load	$550\left(\frac{L}{2}+a+b\right)$	$\frac{x+a+b}{2}$	$-275(x+a+b)\left(\frac{L}{2}+a+b\right)$
—	End shock Load Pulling	$w\left(\frac{L}{2}+a+b\right)$	$\frac{x+a+b}{2}$	$-\frac{w}{2}(x+a+b)\left(\frac{L}{2}+a+b\right)$

FIG. 9.

We have noted that the recommendation of a standard center sill area is not feasible if uniformity in strength is to be considered of more importance than uniformity in the sizes of beams for this element of the underframe. There is, however, a certain portion of the area of the box girder center sills which could be adopted as a standard and the desired result of uniform strength still be secured. The section of the structural beams could be thus specified and the increased resistance at the various sections to take care of the disturbing strains for increased car length or variety of lading be provided by the proper use of cover plates.

A study of the cars built for similar service conditions upon the various railroads yields no idea as to just what the general opinion of car designers would be in respect to the size of such area. The range as now in service extends from a little over 10 square inches to 55. This is a very wide variation. Probable 25 square inches in the channels or I beams would be most convenient to meet the requirements of strength as noted in our previous article upon end shock.

Uniformity in specifications for end shock and strength required at such a shock would seem to be necessary before uniformity in basic area could be secured. The one naturally follows the other.

Again, this uniform area would be affected by the character of the form of load transference. The adoption of standard areas then would seem to be required for each form of load acceptance.

The Side Girder.

The side girder in this car differs from that of the previous form in being a continuous beam of two equal and one unequal spans, with a uniform lading upon them. The moment formulæ developed for such beams is applicable to this girder. Where the girder is cut by a door, placed over the cantilever, the condition becomes that of a simple ended beam at this point for all purposes of calculation. This is not quite true since the side sill angle is continuous and the door posts are tied at the top very securely, but such an assumption errs on the side of increased safety. The door opening arrangement through the girder may make beams of various character of end support or fastening out of the beam. This girder must be examined for deflection and of the types of beams, that of the continuous beam is least dealt with in text books in so far as deflection is concerned. To develop a formula for the deflection of such a girder it is necessary to integrate the tangent formula:

$$24EI\frac{dy}{dx} = 12M_n(2x - l_n) + 4V_n(3x^2 - l^2_n) - [W_n(4x^3 - l^3_n)]$$

This operation carried out and the constant of integration evaluated from the relations that $y = o$ when $x = o$ and also $x = l_n$ will give:

$$24EIy = 12M_n(x^2 - l_nx) + 4V_n(x^3 - l^2_nx) - W_n(x^4 - l^3_nx)$$

Substituting in this the value of:

$$V_n = \frac{M_{n+1} - M_n + \frac{1}{2}W_nl^2_n}{l_n}$$

and remembering that $y = \Delta$ (a maximum) when $x = \frac{1}{2}\,l_n$ there results:

$$\Delta = \frac{l^2_n}{16EI}(M_n + M_{n+1}) - \frac{1}{384EI}W_nl^4_n$$

This, then, is the general formula for the deflection of the central point of a uniformly loaded continuous beam.

A final investigation should show these deflections to be inappreciable. The point of greatest deflection will be found to be located at the center of the car. If the points of center-sill support for the side girder all deflect together and the deflection of the side girder is minute, the alignment of the side sills will always present the appearance of the straight line that it should.

The side girder of this form carries but the superstructure load and need not be of a similar strength for the same length as that of the first form which does all the load carrying.

It is well to note that in this type of girder the changing moments cause a greater portion of the bottom chord to be the compression member than is found in the beam with overhanging ends in the Form I. This is as it should be for load carrying, as less duty is here imposed upon the posts than in the reverse condition.

The resisting moment is the same in form as of side girder for Form I. In general it is the resistance of a plate girder considering the web plate to really perform its share of the load carrying burden.

This discussion of Form II. but supplements the general underframe remarks in the December, 1907, and the January, 1908, issues. The limitations governing weight; economy as concerns initial cost, maintenance and repair and transportation costs; reliability; and the general limitations of comfort, convenience, sanitation and æsthetics, together with the limitations imposed by special services, are there dealt with in detail. The strength and reliability factors for end shocks and vertical lading for the various services are considered and the underframe and side girder tersely discussed in general. The general theory of design for the center sills is also worked out, both graphically and analytically in those sections.

Catalogs Wanted.—Mr. T. S. Reilly, mechanical superintendent of the Yueh-Han Railway Company, Limited, Wong Sha, Canton, China, advises that he will be pleased to receive catalogs and circular matter, price and discount lists, of shop machinery, car and locomotive equipment, etc. The main line of this road, in operation at present, is about thirty-nine miles in length. Work is being rushed to get the first 250 miles constructed. At present seventeen locomotives are in service and three more have been ordered.

Canadian Railway Club Scholarship.—Mr. James Powell, secretary of the Canadian Railway Club, Box 7, St. Lambert, Quebec, announces that examinations for the four-year scholarship in applied science, at McGill University, will be held on June 15. This examination is open to minor sons of members.

GENERAL TOOL SYSTEM

ATCHISON, TOPEKA & SANTA FÉ RAILWAY.

Previous issues of this journal have called special attention to the comprehensive betterment work undertaken in the motive power department of the Santa Fé. This work was inaugurated early in 1904, at a time of labor difficulties and upon completion of one of the largest locomotive repair shops in the country, at Topeka. At the same time the managing officers undertook to make adequate provision for an immensely increasing traffic, that was clearly foreseen, by the acquisition of a large number of the most modern and very heavy locomotives for both passenger and freight service.

In undertaking the betterment work it was the desire of the management to use this motive power to the best advantage and at the same time to keep the repair costs of these large and new types of engines within a reasonable figure. Most of the locomotives were compounds, many of them of the balanced type. In order to adequately take care of the shopping of these engines, and to carry out thoroughly a system of standardization jigs, devices and facilities that would lighten the labor of the men and increase their output capacity, thus acting as an almost inseparable adjunct to the introduction of an individual effort system of reward.

Third. The betterment of machines, including motors, shafting, pulleys, etc.

Fourth. To effect simultaneously with these results an economy in the excessive expenditures for tools of all kinds, by eliminating waste, introducing more durable and serviceable types, and avoiding undesirable investments.

Fifth. The close and detail supervision of tools, machines and methods in railroad work, as it is found by Fred W. Taylor to be, in commercial work, an indispensable factor of shop betterment and individual labor reward; it is, moreover, possible to effect many cost reductions by the methods alone, irrespective of the labor stimulus, as in the case of cylinder and eccentric drilling jigs and other jigs.

FIG. 1.—MANUFACTURING TOOL ROOM FOR THE SANTA FE SYSTEM AT THE TOPEKA SHOPS.

of locomotive parts, centrally manufactured at the Topeka shops, it was realized that the tool and machinery equipments of the shops and the methods of doing the work must be the very best. For this reason special attention was directed to the tool and machinery problem at the beginning of the betterment work, an attention which has been consistently followed up to the present time.

While the technical journals have made some mention of this phase of the work, its importance as the keystone in the arch of betterment and economy for the production of efficiency has, perhaps, been lost sight of in the more extensive mention that has been made of matters of greater magnitude in the gross amount of costs involved.

The purpose of this article is to consider the details of this remarkably successful application of commercial tool methods to railway shop practice. The plan of this supervision comprised:

First. The use of tools that would foster the wholesale production of standard locomotive and car parts at the central shop.

Second. The development and application of special tools,

This involved the development and manufacture of many classes of tools as indicated in the following synopsis:

1.—General tools and devices for use generally over a large part of the work and in almost all shops, including:

a—Three sizes of bevel gear angle device for getting into restricted quarters with an air motor. See Fig. 2.

b—High speed flat drill chucks, No. 5 Morse taper shank. See page 458, December, 1906, issue.

c—Knuckle joint reamers.

d—Universal joints for reaming in restricted quarters.

e—Standard punches, stocks and couplings. See page 459, December, 1906, issue.

f—Standard worm driven air hoist. Fig. 3.

g—Standard blacksmith tools. Illustrated by flatter shown in Fig. 4.

h—Standard rivet snaps.

i—Standard high-speed lathe, planer and boring tools.

k—Various standard taper reamers for erecting work, such as:

dent of the end shock and is found from equating the end moments:

$$150{,}000\,(1+\Delta') = \frac{W}{2}\left(\frac{L}{2} + a + b\right)^2$$

The one approximation in this analysis is the assumption upon which the values of P are based. These are quite near to being correct without much calculation. To be precise, they are the reactions from the three span continuous side girder. The same remark will hold true in the graphical analysis and the moment curves at the center of the car will be reduced by the elimination of the central loads.

+ ↑ — ↓		Forces in pounds	Arm to section in feet	Bending moment in foot pounds
—	Reaction	$P_1 + P_2 + P_3 + \left(\frac{L}{2} + a + b\right)(550 + w)$	x	$P_1x + P_2x + P_3x + (w + 550)\left(\frac{L}{2} + a + b\right)x$
	Platform end sill	P_1	$x + a + b$	$-P_1x - P_1a - P_1b$
	Body end sill	P_2	$x + b$	$-P_2x - P_2b$
	Inter-Cantilever	P_3	$x - c$	$-P_3x + P_3c$
	Uniform centre sill Load	$550\left(\frac{L}{2} + a + b\right)$	$\frac{x + a + b}{2}$	$275\,(x + a + b)\left(\frac{L}{2} + a + b\right)$
	End shock Load Pulling	$w\left(\frac{L}{2} + a + b\right)$	$\frac{x + a + b}{2}$	$\frac{w}{2}(x + a + b)\left(\frac{L}{2} + a + b\right)$

FIG. 9.

We have noted that the recommendation of a standard center sill area is not feasible if uniformity in strength is to be considered of more importance than uniformity in the sizes of beams for this element of the underframe. There is, however, a certain portion of the area of the box girder center sills which could be adopted as a standard and the desired result of uniform strength still be secured. The section of the structural beams could be thus specified and the increased resistance at the various sections to take care of the disturbing strains for increased car length or variety of lading be provided by the proper use of cover plates.

A study of the cars built for similar service conditions upon the various railroads yields no idea as to just what the general opinion of car designers would be in respect to the size of such area. The range as now in service extends from a little over 10 square inches to 55. This is a very wide variation. Probable 25 square inches in the channels or I beams would be most convenient to meet the requirements of strength as noted in our previous article upon end shock.

Uniformity in specifications for end shock and strength required at such a shock would seem to be necessary before uniformity in basic area could be secured. The one naturally follows the other.

Again, this uniform area would be affected by the character of the form of load transference. The adoption of standard areas then would seem to be required for each form of load acceptance.

THE SIDE GIRDER.

The side girder in this car differs from that of the previous form in being a continuous beam of two equal and one unequal spans, with a uniform lading upon them. The moment formulæ developed for such beams is applicable to this girder. Where the girder is cut by a door, placed over the cantilever, the condition becomes that of a simple ended beam at this point for all purposes of calculation. This is not quite true since the side sill angle is continuous and the door posts are tied at the top very securely, but such an assumption errs on the side of increased safety. The door opening arrangement through the girder may make beams of various character of end support or fastening out of the beam. This girder must be examined for deflection and of the types of beams, that of the continuous beam is least dealt with in text books in so far as deflection is concerned. To develop a formula for the deflection of such a girder it is necessary to integrate the tangent formula:

$$24EI\frac{dy}{dx} = 12M_n(2x - l_n) + 4V_n(3x^2 - l^2_n) - [W_n(4x^3 - l^3_n)]$$

This operation carried out and the constant of integration evaluated from the relations that $y = 0$ when $x = 0$ and also $x = l_n$ will give:

$$24EIy = 12M_n(x^2 - l_nx) + 4V_n(x^3 - l^2_nx) - W_n(x^4 - l^3_nx)$$

Substituting in this the value of:

$$V_n = \frac{M_{n+1} - M_n + \frac{1}{2}W_nl^2_n}{l_n}$$

and remembering that $y = \Delta$ (a maximum) when $x = \frac{l_n}{2}$ there results:

$$\Delta = -\frac{l^2_n}{16EI}(M_n + M_{n+1}) - \frac{1}{384EI}W_nl^4_n$$

This, then, is the general formula for the deflection of the central point of a uniformly loaded continuous beam.

A final investigation should show these deflections to be inappreciable. The point of greatest deflection will be found to be located at the center of the car. If the points of center-sill support for the side girder all deflect together and the deflection of the side girder is minute, the alignment of the side sills will always present the appearance of the straight line that it should.

The side girder of this form carries but the superstructure load and need not be of a similar strength for the same length as that of the first form which does all the load carrying.

It is well to note that in this type of girder the changing moments cause a greater portion of the bottom chord to be the compression member than is found in the beam with overhanging ends in the Form I. This is as it should be for load carrying, as less duty is here imposed upon the posts than in the reverse condition.

The resisting moment is the same in form as of side girder for Form I. In general it is the resistance of a plate girder considering the web plate to really perform its share of the load carrying burden.

This discussion of Form II. but supplements the general underframe remarks in the December, 1907, and the January, 1908, issues. The limitations governing weight; economy as concerns initial cost, maintenance and repair and transportation costs; reliability; and the general limitations of comfort, convenience, sanitation and æsthetics, together with the limitations imposed by special services, are there dealt with in detail. The strength and reliability factors for end shocks and vertical lading for the various services are considered and the underframe and side girder tersely discussed in general. The general theory of design for the center sills is also worked out, both graphically and analytically in those sections.

CATALOGS WANTED.—Mr. T. S. Reilly, mechanical superintendent of the Yueh Han Railway Company, Limited, Wong Sha, Canton, China, advises that he will be pleased to receive catalogs and circular matter, price and discount lists, of shop machinery, car and locomotive equipment, etc. The main line of this road, in operation at present, is about thirty-nine miles in length. Work is being rushed to get the first 250 miles constructed. At present seventeen locomotives are in service and three more have been ordered.

CANADIAN RAILWAY CLUB SCHOLARSHIP.—Mr. James Powell, secretary of the Canadian Railway Club, Box 7, St. Lambert, Quebec, announces that examinations for the four-year scholarship in applied science, at McGill University, will be held on June 15. This examination is open to minor sons of members

GENERAL TOOL SYSTEM

Atchison, Topeka & Santa Fé Railway.

Previous issues of this journal have called special attention to the comprehensive betterment work undertaken in the motive power department of the Santa Fé. This work was inaugurated early in 1904, at a time of labor difficulties and upon completion of one of the largest locomotive repair shops in the country, at Topeka. At the same time the managing officers undertook to make adequate provision for an immensely increasing traffic, that was clearly foreseen, by the acquisition of a large number of the most modern and very heavy locomotives for both passenger and freight service.

In undertaking the betterment work it was the desire of the management to use this motive power to the best advantage and at the same time to keep the repair costs of these large and new types of engines within a reasonable figure. Most of the locomotives were compounds, many of them of the balanced type. In order to adequately take care of the shopping of these engines, and to carry out thoroughly a system of standardization of locomotive parts, centrally manufactured at the Topeka shops, it was realized that the tool and machinery equipments of the shops and the methods of doing the work must be the very best. For this reason special attention was directed to the tool and machinery problem at the beginning of the betterment work, an attention which has been consistently followed up to the present time.

While the technical journals have made some mention of this phase of the work, its importance as the keystone in the arch of betterment and economy for the production of efficiency has, perhaps, been lost sight of in the more extensive mention that has been made of matters of greater magnitude in the gross amount of costs involved.

The purpose of this article is to consider the details of this remarkably successful application of commercial tool methods to railway shop practice. The plan of this supervision comprised:

First. The use of tools that would foster the wholesale production of standard locomotive and car parts at the central shop.

Second. The development and application of special tools, jigs, devices and facilities that would lighten the labor of the men and increase their output capacity, thus acting as an almost inseparable adjunct to the introduction of an individual effort system of reward.

Third. The betterment of machines, including motors, shafting, pulleys, etc.

Fourth. To effect simultaneously with these results an economy in the excessive expenditures for tools of all kinds, by eliminating waste, introducing more durable and serviceable types, and avoiding undesirable investments.

Fifth. The close and detail supervision of tools, machines and methods in railroad work, as it is found by Fred W. Taylor to be, in commercial work, an indispensable factor of shop betterment and individual labor reward; it is, moreover, possible to effect many cost reductions by the methods alone, irrespective of the labor stimulus, as in the case of cylinder and eccentric drilling jigs and other jigs.

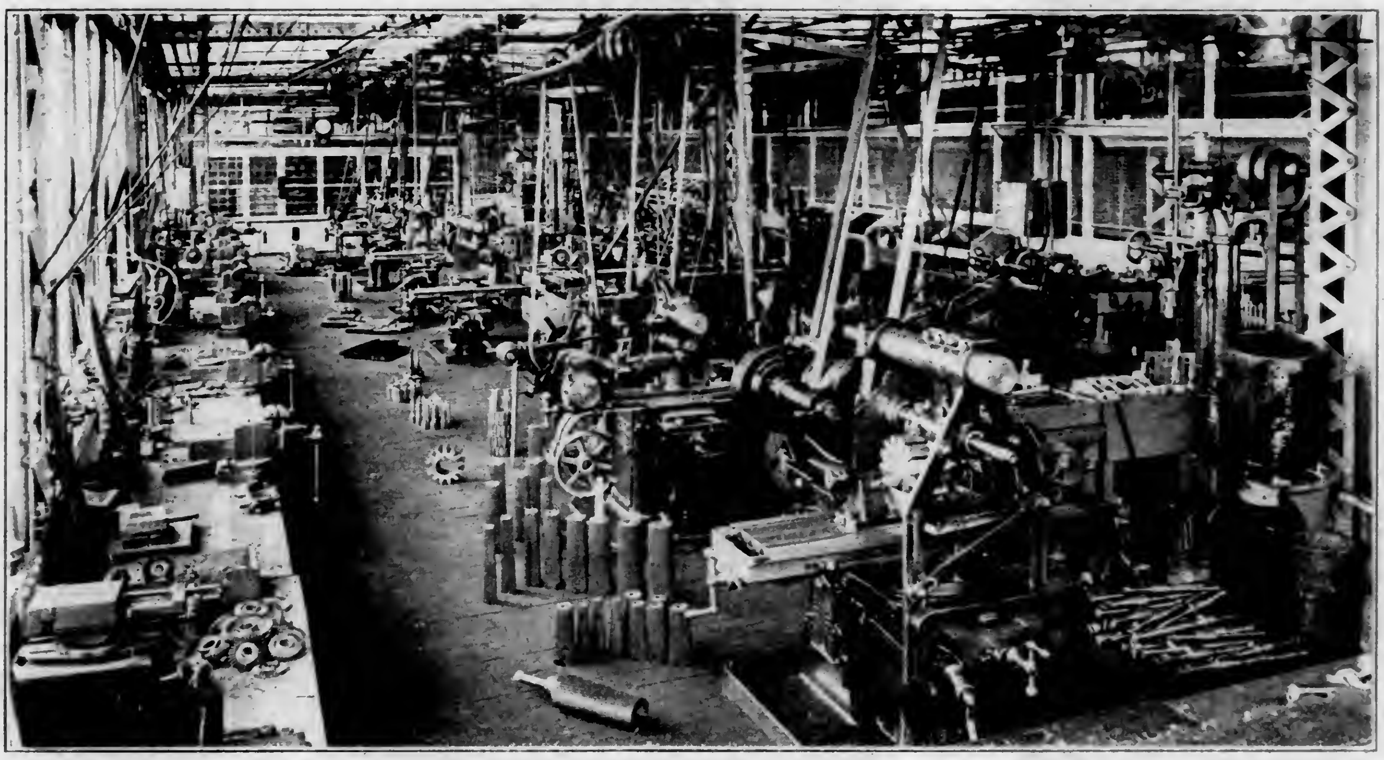


FIG. 1.—MANUFACTURING TOOL ROOM FOR THE SANTA FE SYSTEM AT THE TOPEKA SHOPS.

This involved the development and manufacture of many classes of tools as indicated in the following synopsis:

1.—General tools and devices for use generally over a large part of the work and in almost all shops, including:

- a—Three sizes of bevel gear angle device for getting into restricted quarters with an air motor. See Fig. 2.
- b—High speed flat drill chucks, No. 5 Morse taper shank. See page 458, December, 1906, issue.
- c—Knuckle joint reamers.
- d—Universal joints for reaming in restricted quarters.
- e—Standard punches, stocks and couplings. See page 459, December, 1906, issue.
- f—Standard worm driven air hoist. Fig. 3.
- g—Standard blacksmith tools. Illustrated by flatter shown in Fig. 4.
- h—Standard rivet snaps.
- i—Standard high-speed lathe, planer and boring tools.
- k—Various standard taper reamers for erecting work, such as:

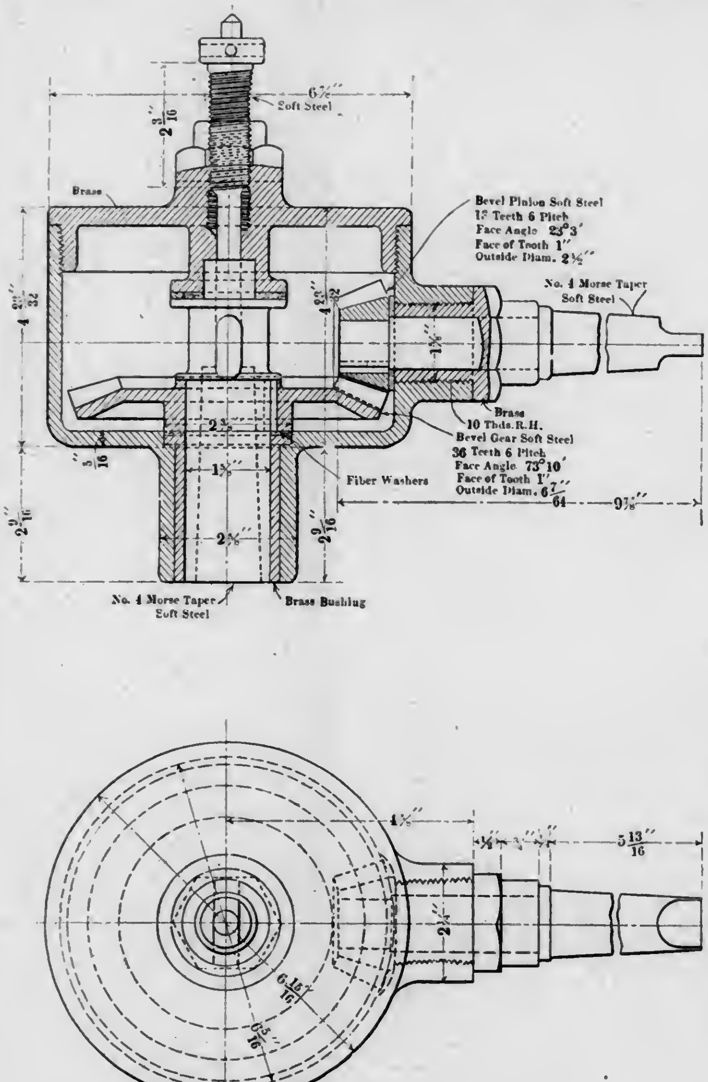


FIG. 2.—ANGLE DEVICE FOR DRILLING AND REAMING IN CLOSE QUARTERS. THREE SIZES ARE MADE, THE ILLUSTRATION SHOWING THE LARGEST.

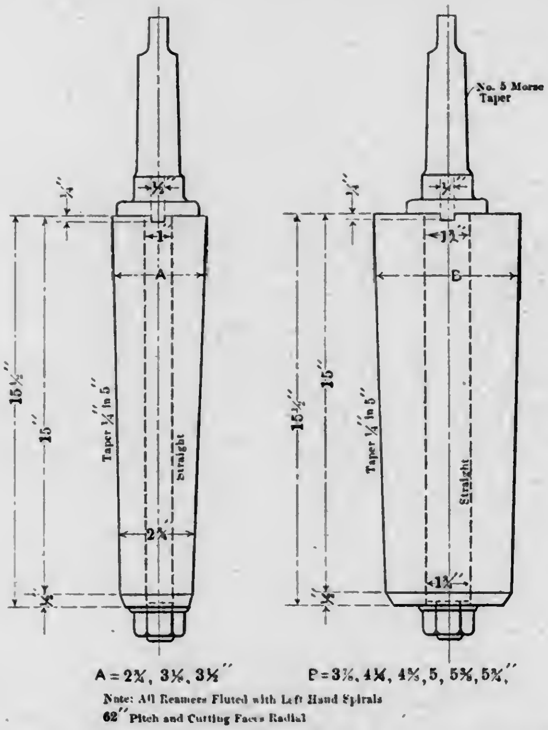


FIG. 5.—STANDARD CROSSHEAD AND PISTON REAMERS. THERE ARE NINE SIZES IN ALL WITH DIAMETERS VARYING BY THREE-EIGHTHS OF AN INCH. THE THREE SMALLER SIZES ARE MOUNTED ON 1-IN. ARBORS AND THE SIX LARGER SIZES ON 1¾-IN. ARBORS. ALL OTHER DIMENSIONS ARE UNIFORM.

Standard taper reamers for blade pins used on all standard classes of engines, thus making it possible to manufacture blade pins on an automatic machine.

Standard taper knuckle joint pin reamers used on all classes of engines, reducing the number of reamers in each shop to only four.

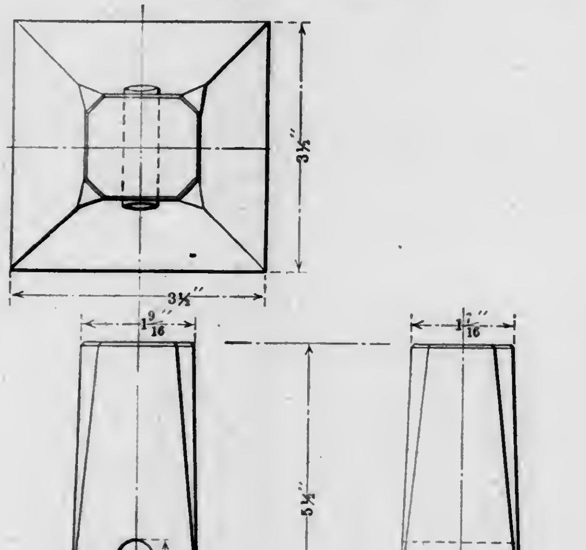


FIG. 4.—STANDARD BLACKSMITH FLATTER. AN EXAMPLE OF ECONOMICAL STEAM HAMMER FORGING.

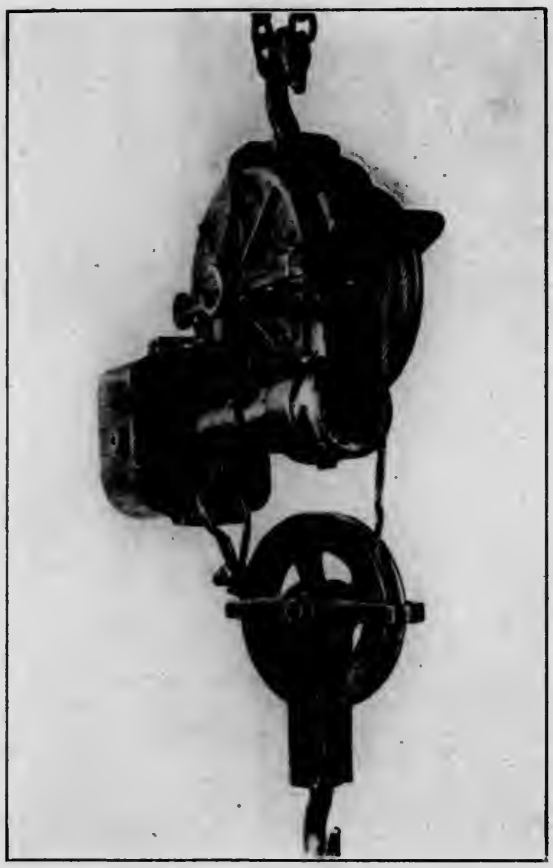


FIG. 3.—STANDARD MOTOR BLOCK AND TACKLE, DESIGNED AND BUILT IN TOPEKA TOOL ROOM. AN EXAMPLE OF CAPACITY FOR REFINED MANUFACTURE.

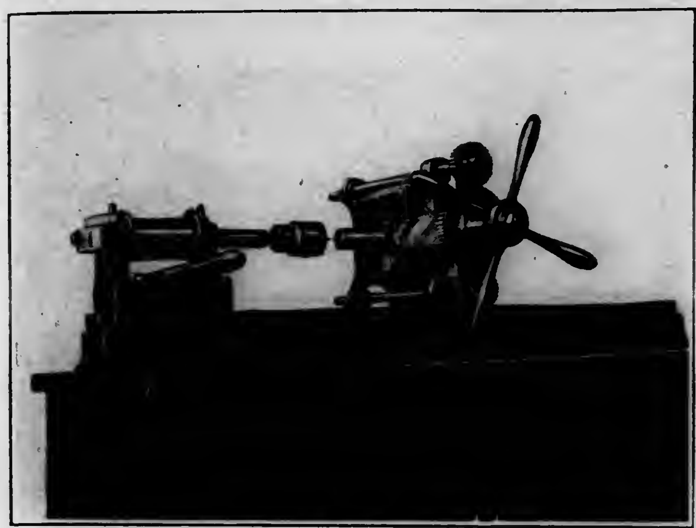


FIG. 8.—CENTERING MACHINE DESIGNED AND BUILT IN CENTRAL TOOL ROOM. THE COST OF THE MACHINE IS LOW; IT IS RAPID AND ACCURATE IN OPERATION.

the shops. (See pages 458 and 459, December, 1906, issue.)

2.—Special devices, such as mandrels and chucks, to facilitate the machining of various classes of work.

3.—Jigs—attachments to machines for the economical production of various kinds of work.

4.—Templets and jigs, such as illustrated in Fig. 7, to obviate the necessity of laying out work. Includes jigs and templets for:

a—Drilling steam chest stud holes.
b—Drilling cylinder stud holes.
c—Drilling cylinder saddles, cylinder heads, valve chamber heads, spiders, follower plates, eccentric straps, steam pipe elbows, packing glands.
d—Laying off driving box brasses.
e—Drilling flue roller casings.

5.—Special machines:

a—Centering machine, illustrated in Fig. 8.
b—Snap ring packing ring milling machine. See page 334, September, 1904, issue.
c—Crank axle pin turning machine. See "The Solution of the Crank Axle Problem," in this issue.

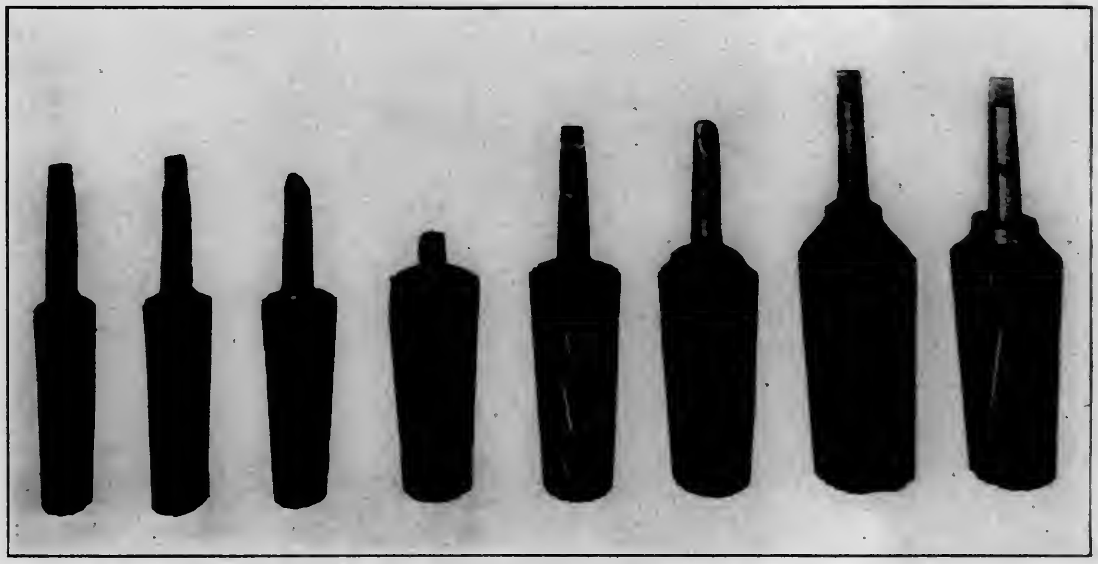


FIG. 6.—THE KIND OF REAMERS, WITHOUT STANDARDS AS TO SIZE, TAPER, LENGTH, OR MANNER OF CONSTRUCTION AND DESIGN, THAT RESULTED IN ONE SHOP FROM THE WORKING OUT OF THE IDEAS OF THE INDIVIDUAL FOREMAN. THESE REAMERS ARE THEMSELVES NOT ONLY SEVERALLY MORE EXPENSIVE TO CONSTRUCT THAN THE STANDARD ONES, AND LESS EFFICIENT IN OPERATION, BUT THEY ALSO MAKE THE WORK ON THE LOCOMOTIVES VERY COSTLY IN REPAIRS AND REPLACEMENTS.

Standard taper link motion pin reamers. Standardizing the taper on all link motion pins of all engines will not only reduce the number of reamers at each point to a minimum, but will make it possible to concentrate the manufacture of pins at a central point, supplying all outside points on requisitions.

Standard crosshead reamers. The taper on piston, crosshead, and wrist pin fits was standardized for all classes of engines on the system, reducing the number of reamers to only nine as shown in Fig. 5.

Standard reamers for reaming frame holes to standard sizes, making it possible to concentrate the manufacture of finished engine bolts for the system at Topeka, thus using the automatic bolt machine to its full capacity.

Besides these, nine special standard ball joint reamers, with inserted blades diametrically opposed but unevenly spaced, were shipped to the principal points on the system in order that a standard radius might be made on all steam pipes on engines passing through

FIG. 7.—CYLINDER, CYLINDER HEAD AND STEAM CHEST JIGS FOR DRILLING STUD HOLES ACCURATELY, THUS INSURING THE USE OF STANDARD MANUFACTURED PARTS. HARDENED STEEL BUSHINGS FOR THE VARIOUS SIZES OF DRILLS ARE PROVIDED WITH THESE JIGS.

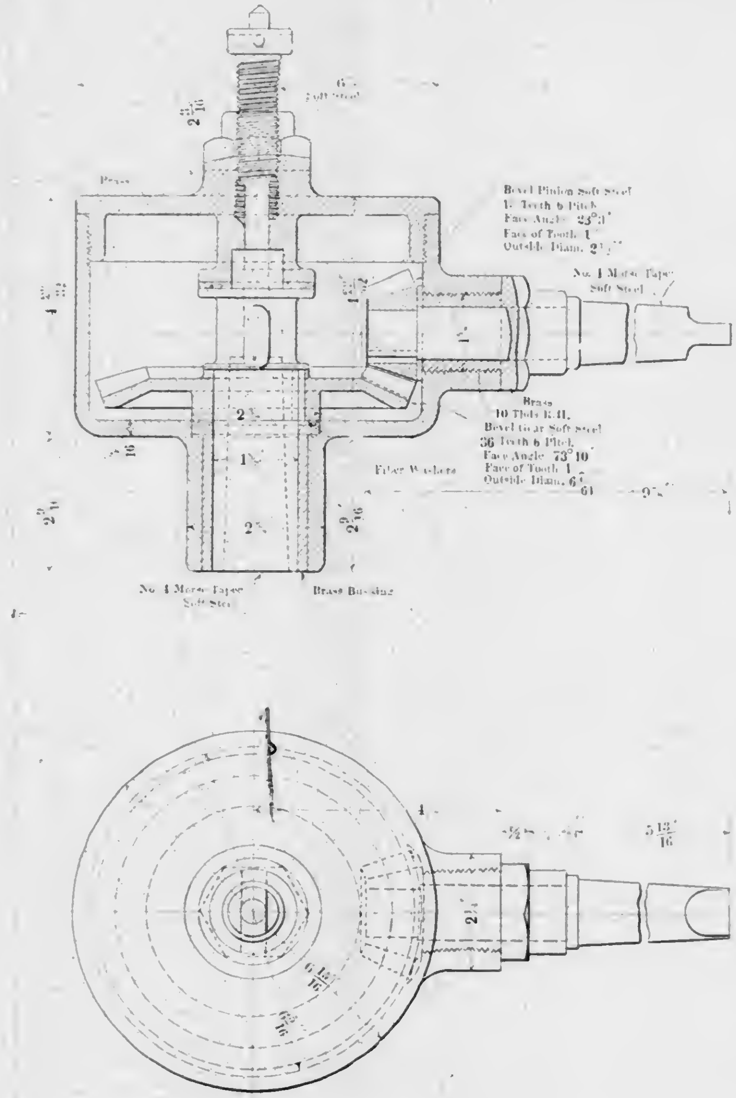


FIG. 2.—ANGLE DEVICE FOR DRILLING AND REAMING IN CLOSE QUARTERS. THREE SIZES ARE MADE, THE ILLUSTRATION SHOWING THE LARGEST.

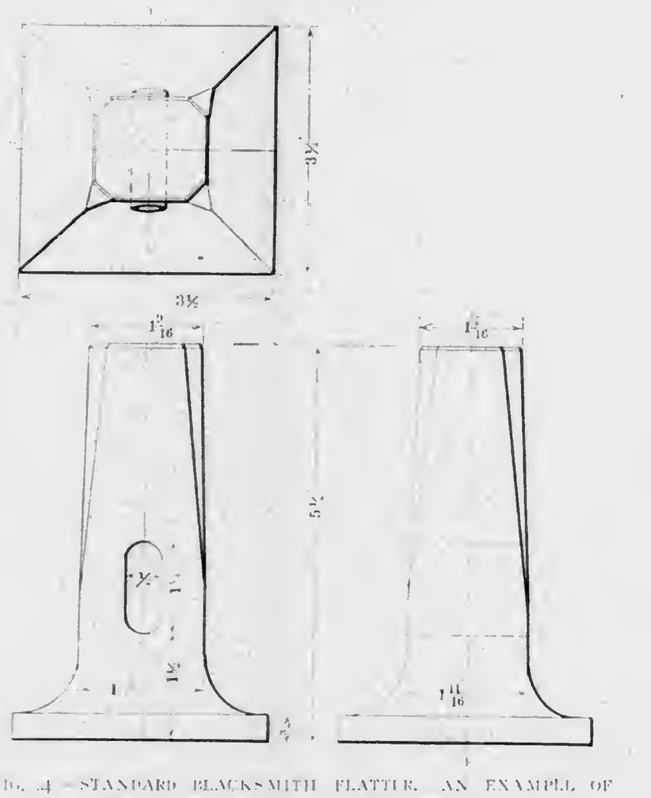


FIG. 4.—STANDARD BLACKSMITH FLATTER. AN EXAMPLE OF ECONOMICAL STEAM HAMMER FORGING.

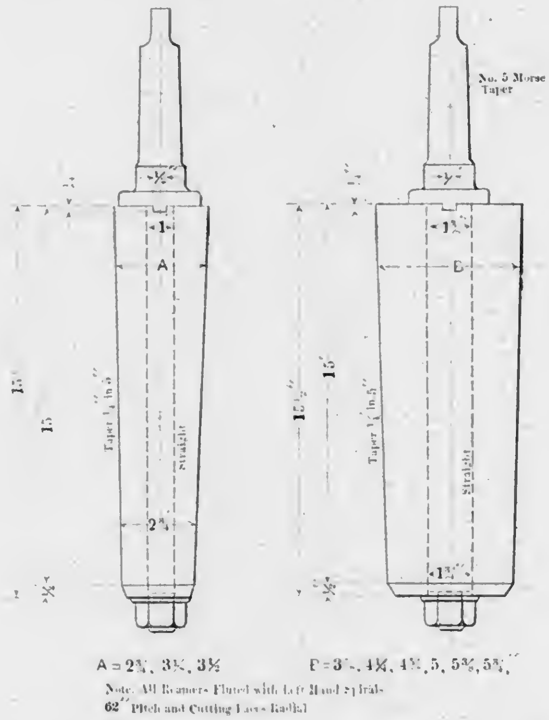


FIG. 5.—STANDARD CROSSHEAD AND PISTON REAMERS. THERE ARE NINE SIZES IN ALL WITH DIAMETERS VARYING BY THREE-EIGHTHS OF AN INCH. THE THREE SMALLER SIZES ARE MOUNTED ON 1-IN. ARBORS AND THE SIX LARGER SIZES ON 1¾-IN. ARBORS. ALL OTHER DIMENSIONS ARE UNIFORM.

Standard taper reamers for blade pins used on all standard classes of engines, thus making it possible to manufacture blade pins on an automatic machine.

Standard taper knuckle joint pin reamers used on all classes of engines, reducing the number of reamers in each shop to only four.

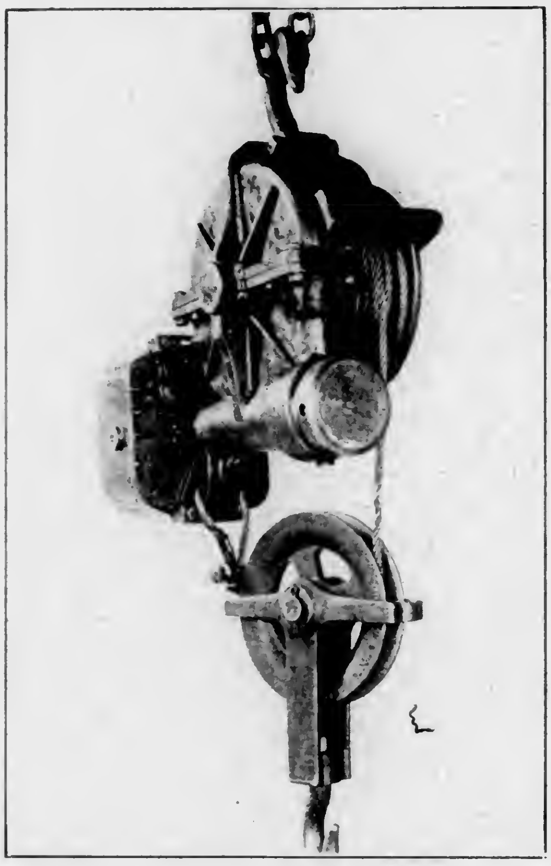


FIG. 3.—STANDARD MOTOR BLOCK AND TACKLE, DESIGNED AND BUILT IN TOPEKA TOOL ROOM. AN EXAMPLE OF CAPACITY FOR REFINED MANUFACTURE.

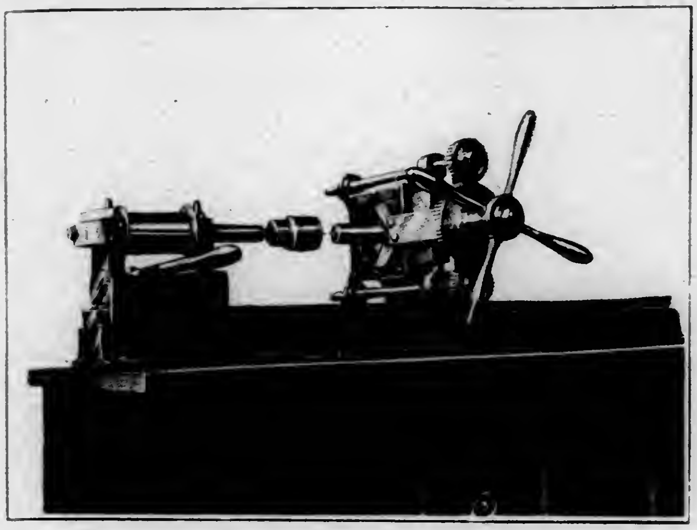


FIG. 8.—CENTERING MACHINE DESIGNED AND BUILT IN CENTRAL TOOL ROOM. THE COST OF THE MACHINE IS LOW; IT IS RAPID AND ACCURATE IN OPERATION.

the shops. (See pages 458 and 459, December, 1906, issue.)

2.—Special devices, such as mandrels and chucks, to facilitate the machining of various classes of work.

3.—Jigs—attachments to machines for the economical production of various kinds of work.

4.—Templets and jigs, such as illustrated in Fig. 7, to obviate the necessity of laying out work. Includes jigs and templets for:

a—Drilling steam chest stud holes.
b—Drilling cylinder stud holes.
c—Drilling cylinder saddles, cylinder heads, valve chamber heads, spiders, follower plates, eccentric straps, steam pipe elbows, packing glands.
d—Laying off driving box brasses.
e—Drilling flue roller casings.

5.—Special machines:

a—Centering machine, illustrated in Fig. 8.
b—Snap ring packing ring milling machine. See page 354, September, 1904, issue.
c—Crank axle pin turning machine. See "The Solution of the Crank Axle Problem," in this issue.

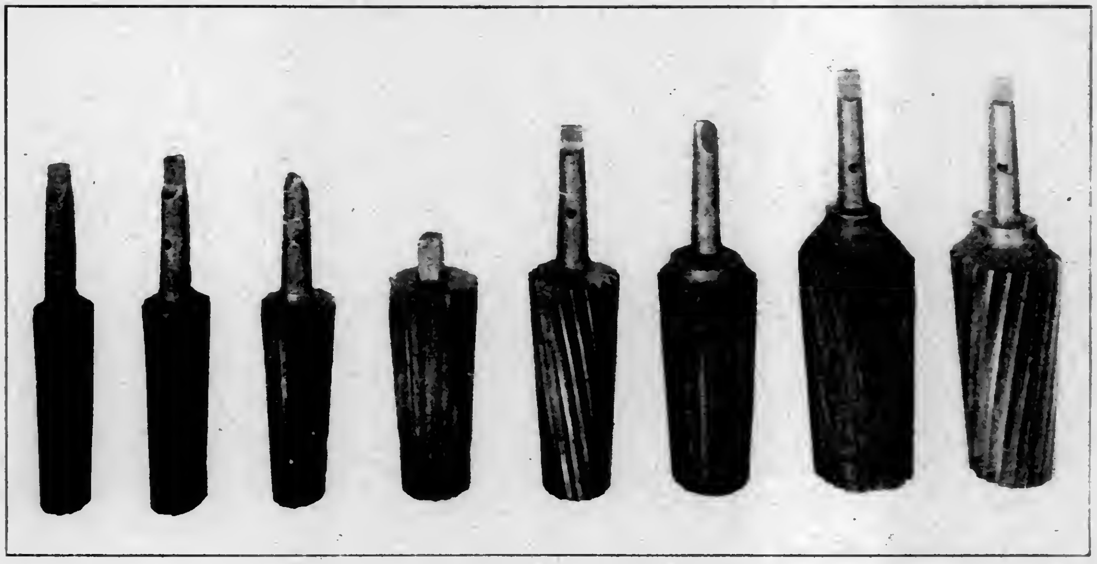


FIG. 6.—THE KIND OF REAMERS, WITHOUT STANDARDS AS TO SIZE, TAPER, LENGTH, OR MANNER OF CONSTRUCTION AND DESIGN, THAT RESULTED IN ONE SHOP FROM THE WORKING OUT OF THE IDEAS OF THE INDIVIDUAL FOREMAN. THESE REAMERS ARE THEMSELVES NOT ONLY SEVERALLY MORE EXPENSIVE TO CONSTRUCT THAN THE STANDARD ONES, AND LESS EFFICIENT IN OPERATION, BUT THEY ALSO MAKE THE WORK ON THE LOCOMOTIVES VERY COSTLY IN REPAIRS AND REPLACEMENTS.

Standard taper link motion pin reamers. Standardizing the taper on all link motion pins of all engines will not only reduce the number of reamers at each point to a minimum, but will make it possible to concentrate the manufacture of pins at a central point, supplying all outside points on requisitions.

Standard crosshead reamers. The taper on piston, crosshead, and wrist pin fits was standardized for all classes of engines on the system, reducing the number of reamers to only nine as shown in Fig. 5.

Standard reamers for reaming frame holes to standard sizes, making it possible to concentrate the manufacture of finished engine bolts for the system at Topeka, thus using the automatic bolt machine to its full capacity.

Besides these, nine special standard ball joint reamers, with inserted blades diametrically opposed but unevenly spaced, were shipped to the principal points on the system in order that a standard radius might be made on all steam pipes on engines passing through

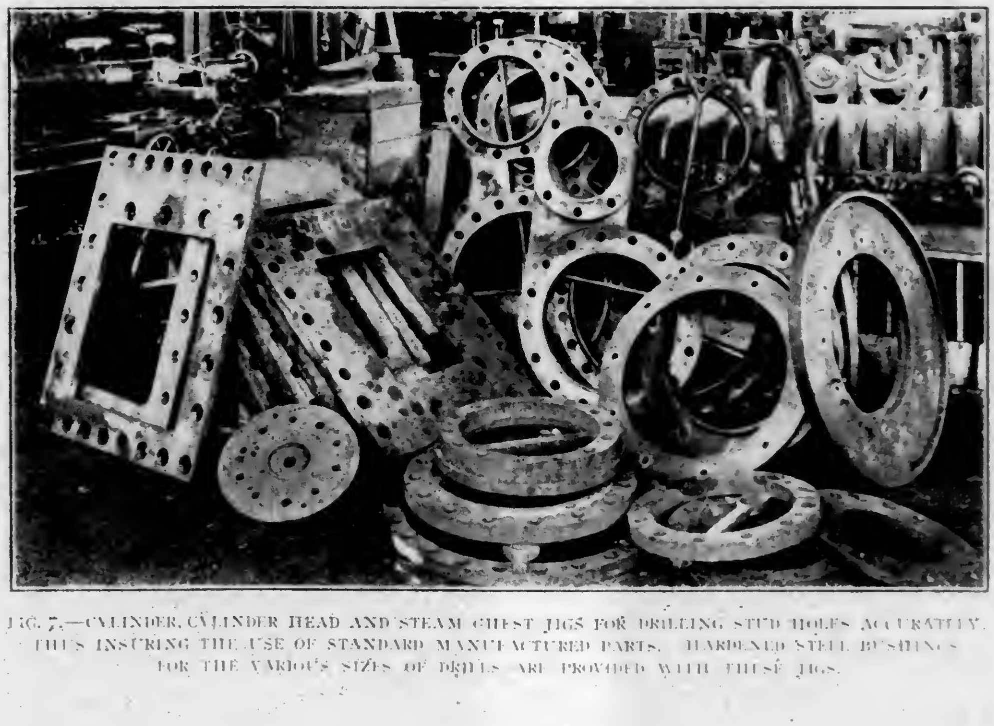


FIG. 7.—CYLINDER, CYLINDER HEAD AND STEAM CHEST JIGS FOR DRILLING STUD HOLES ACCURATELY, THUS INSURING THE USE OF STANDARD MANUFACTURED PARTS. HARDENED STEEL BUSHINGS FOR THE VARIOUS SIZES OF DRILLS ARE PROVIDED WITH THESE JIGS.

d—Complete re-construction of cylinder boring machine, as shown in Fig. 9.

6—Machine improvements:*

a—Speeding up line and countershafts.

b—Pulleys enlarged.

c—Wider driving cones applied.

d—Larger feed cones and gears.

e—Use of bronze worms.

f—Steel gears and pinions.

g—Increase in size of motors for motor drives.

h—Standard abrasive wheel stands. Fig. 10.

7.—High speed milling cutters and gang cutters:

a—For heavy production work on shoes and wedges.

b—Cutters with inserted teeth for side rod channels, eccentrics, eccentric straps, etc.

c—For small accurate work on flanging dies, MCB tire and knuckle gauges, tire finishing tools.

and the work is directly under the supervision of the general tool foreman.

The general storehouse stock of standard tools, as shown in Fig. 12, is an indication of the economy and advantage incident to the policy of centralized standard duplicate manufacture of railway tools, instead of the general practice of each local shop manufacturing individually from individual varying and special designs. Under the new policy not only are the tools more perfectly designed and built, and more cheaply, but the needs of all shops are served more promptly and efficiently by the finished stock at the general storehouse, a stock which is much smaller than would be needed, were each local shop to protect its own requirements.

The foregoing covers in a general way the mechanical features of the tool system, as carried out in successful practice. In order to make the system effective, and maintain an efficient but minimum stock of tools at all shops, a tool stock book is provided.

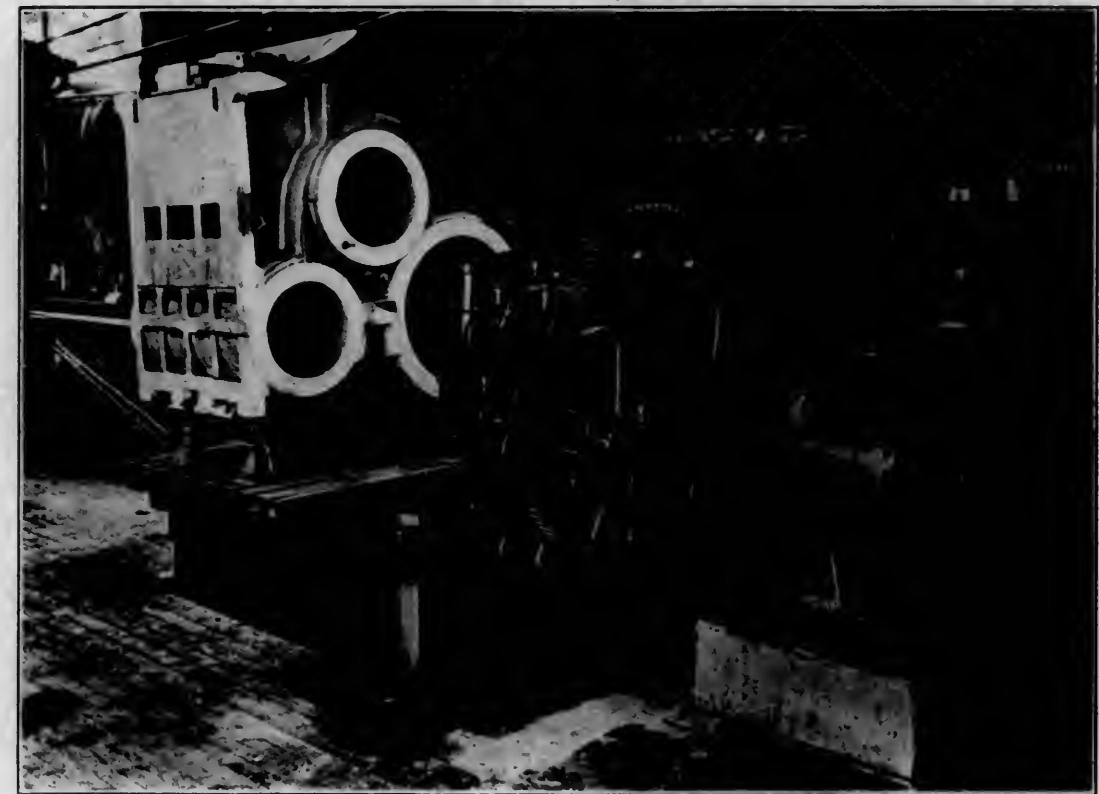


FIG. 9.—IMPROVED CYLINDER BORING MACHINE ENTIRELY RECONSTRUCTED IN RAILROAD SHOP AND TOOL ROOM. THIS IS AN EXAMPLE OF THE FACILITY WITH WHICH EVEN LARGE SPECIAL MACHINES MAY BE PRODUCED BY A THOROUGHLY ARRANGED AND EQUIPPED TOOL ROOM AND FORCE. THIS MACHINE WILL BORE, FACE AND FINISH COMPLETE AN 18-INCH SINGLE CYLINDER IN FROM TWO TO THREE HOURS, WHICH IS EQUAL TO THE PERFORMANCE OF ANY COMMERCIAL TOOL.

The general tool room at Topeka is equipped to handle tool work of every description, having all the facilities and labor-saving devices and methods that have proven really efficient. Examples of lessened costs of production under the new system, with improvd quality of output, may be given:

Turning flue roller pins, former day's output, 8 in 10 hours; present output, 46 in 10 hours.

Milling a 28½" reamer, complete, former time, 7 hours; present time, 3.2 hours.

Forging blacksmith flatter under steam hammer, former cost, 24c.; present cost, 13c.

Another new departure in railroad practice is shown in Fig. 11; this is a special tool hardening room equipped with a gas furnace and annealing ovens, water, oil and air baths, and all facilities for the production of perfect tools without failure. The temperatures for exactly uniform product are determined by an electric pyrometer, and not by color, thus eliminating all chance of error. This room is adjacent to the manufacturing tool room

* See article on "High Speed Steel in Railroad Shops," by Henry W. Jacobs, in the September, 1904, issue.

The sample page of this book, illustrated in Fig. 13, shows the arrangement of columns for keeping a record of tools on hand and on order, by months. The book is ruled so that a double page contains the record for a fiscal year, thus providing a perpetual inventory.

On the first of each month all books are sent to Topeka, along with the monthly requisition for the tools required. The books are then checked up with the requisition and immediately returned. Requisitions for tools are made once each month. A direct supervision over each tool room of the system is thus obtained and the maintenance of the tool room equipment is not left to the individual judgment of each tool room foreman. This method has not only kept down the stock of tools to a minimum but greatly increased the efficiency of every tool room on the system.

The methods, organization and details of operation of the tool system have been covered in a bulletin issued by the assistant superintendent of motive power. This bulletin is posted in all shops of the system for the instruction of both foremen and workmen. By this means all concerned are made familiar

FIG. 11.—TOOL HARDENING ROOM AT TOPEKA SHOPS. HERE ALL THE CUTTING TOOLS MANUFACTURED IN THE TOOL ROOM ARE TEMPERED OR HARDENED.

FIG. 12.—GENERAL STOREHOUSE STOCK OF STANDARD TOOLS MANUFACTURED IN TOOL ROOM AT TOPEKA AND SUBJECT TO REQUISITION FROM ALL OUTLYING SHOPS.

with the rules and regulations of the tool system, and the co-operation which naturally follows has greatly increased the efficiency of tools and tool rooms. . The bulletin referred to is as follows:

TOOL REGULATIONS.

Proper and economical work depends upon the tools used, the condition in which they are kept, and their availability for service when needed. System must be used in the care and distribution of tools, so that excessive amounts of them will not be accumulated, and so that expensive tools

d—Complete re-construction of cylinder boring machine, as shown in Fig. 9.

6—Machine improvements:*

a—Speeding up line and countershafts.
b—Pulleys enlarged.
c—Wider driving cones applied.
d—Larger feed cones and gears.
e—Use of bronze worms.
f—Steel gears and pinions.
g—Increase in size of motors for motor drives.
h—Standard abrasive wheel stands. Fig. 10.

7—High speed milling cutters and gang cutters:

a—For heavy production work on shoes and wedges.
b—Cutters with inserted teeth for side rod channels, eccentrics, eccentric straps, etc.
c—For small accurate work on flanging dies, MCB tire and knuckle gauges, tire finishing tools.

and the work is directly under the supervision of the general tool foreman.

The general storehouse stock of standard tools, as shown in Fig. 12, is an indication of the economy and advantage incident to the policy of centralized standard duplicate manufacture of railway tools, instead of the general practice of each local shop manufacturing individually from individual varying and special designs. Under the new policy not only are the tools more perfectly designed and built, and more cheaply, but the needs of all shops are served more promptly and efficiently by the finished stock at the general storehouse, a stock which is much smaller than would be needed, were each local shop to protect its own requirements.

The foregoing covers in a general way the mechanical features of the tool system, as carried out in successful practice. In order to make the system effective, and maintain an efficient but minimum stock of tools at all shops, a tool stock book is provided.

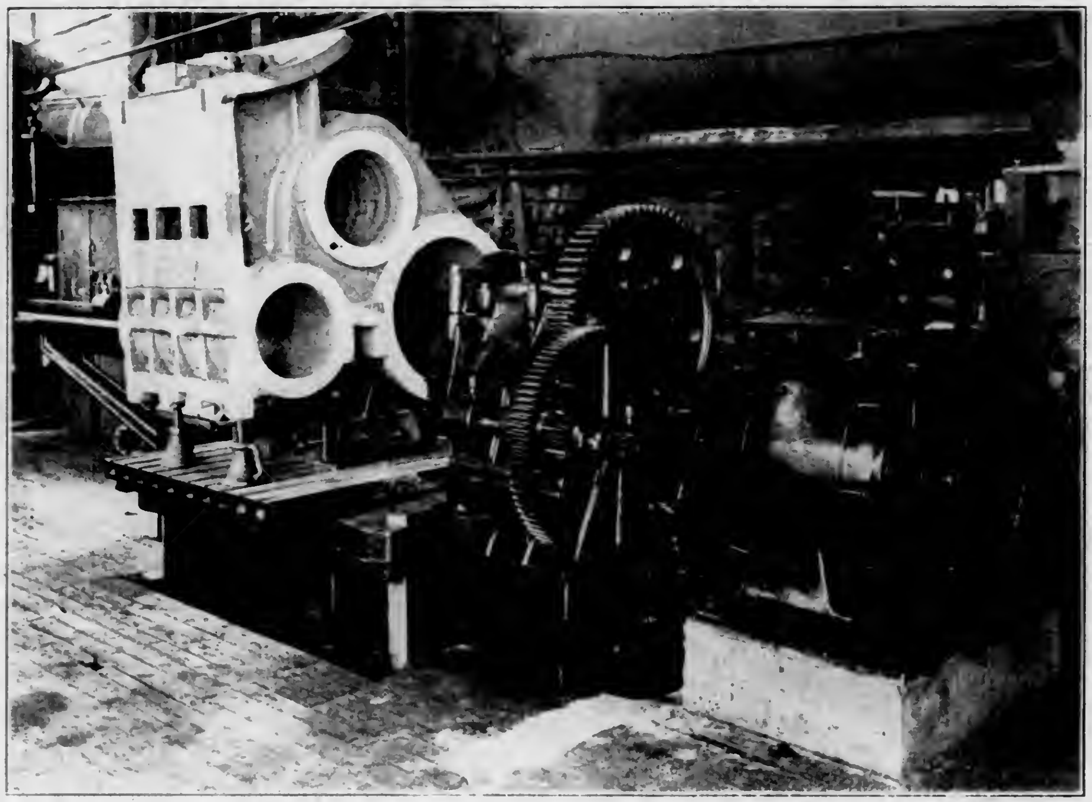


FIG. 9.—IMPROVED CYLINDER BORING MACHINE ENTIRELY RECONSTRUCTED IN RAILROAD SHOP AND TOOL ROOM. THIS IS AN EXAMPLE OF THE FACILITY WITH WHICH EVEN LARGE SPECIAL MACHINES MAY BE PRODUCED BY A THOROUGHLY ARRANGED AND EQUIPPED TOOL ROOM AND FORCE. THIS MACHINE WILL BORE, FACE AND FINISH COMPLETE AN 18-INCH SINGLE CYLINDER IN FROM TWO TO THREE HOURS, WHICH IS EQUAL TO THE PERFORMANCE OF ANY COMMERCIAL TOOL.

The general tool room at Topeka is equipped to handle tool work of every description, having all the facilities and labor saving devices and methods that have proven really efficient. Examples of lessened costs of production under the new system, with improved quality of output, may be given:

Finishing link roller pins, former day's output, 8 in 10 hours; present output, 16 in 10 hours.

Making a 28½" reamer, complete, former time, 7 hours; present time, 3 [illegible] hours.

Forging blacksmith flatter under steam hammer, former cost, 24c.; present cost, 13c.

Another new departure in railroad practice is shown in Fig. 11: this is a special tool hardening room equipped with a gas furnace and annealing ovens, water, oil and air baths, and all facilities for the production of perfect tools without failure. The temperatures for exactly uniform product are determined by an electric pyrometer, and not by color, thus eliminating all chance of error. This room is adjacent to the manufacturing tool room

* See article on "High Speed Steel in Railroad Shops," by Henry W. Jacobs, in the September, 1911, issue.

The sample page of this book, illustrated in Fig. 13, shows the arrangement of columns for keeping a record of tools on hand and on order, by months. The book is ruled so that a double page contains the record for a fiscal year, thus providing a perpetual inventory.

On the first of each month all books are sent to Topeka, along with the monthly requisition for the tools required. The books are then checked up with the requisition and immediately returned. Requisitions for tools are made once each month. A direct supervision over each tool room of the system is thus obtained and the maintenance of the tool room equipment is not left to the individual judgment of each tool room foreman. This method has not only kept down the stock of tools to a minimum but greatly increased the efficiency of every tool room on the system.

The methods, organization and details of operation of the tool system have been covered in a bulletin issued by the assistant superintendent of motive power. This bulletin is posted in all shops of the system for the instruction of both foremen and workmen. By this means all concerned are made familiar

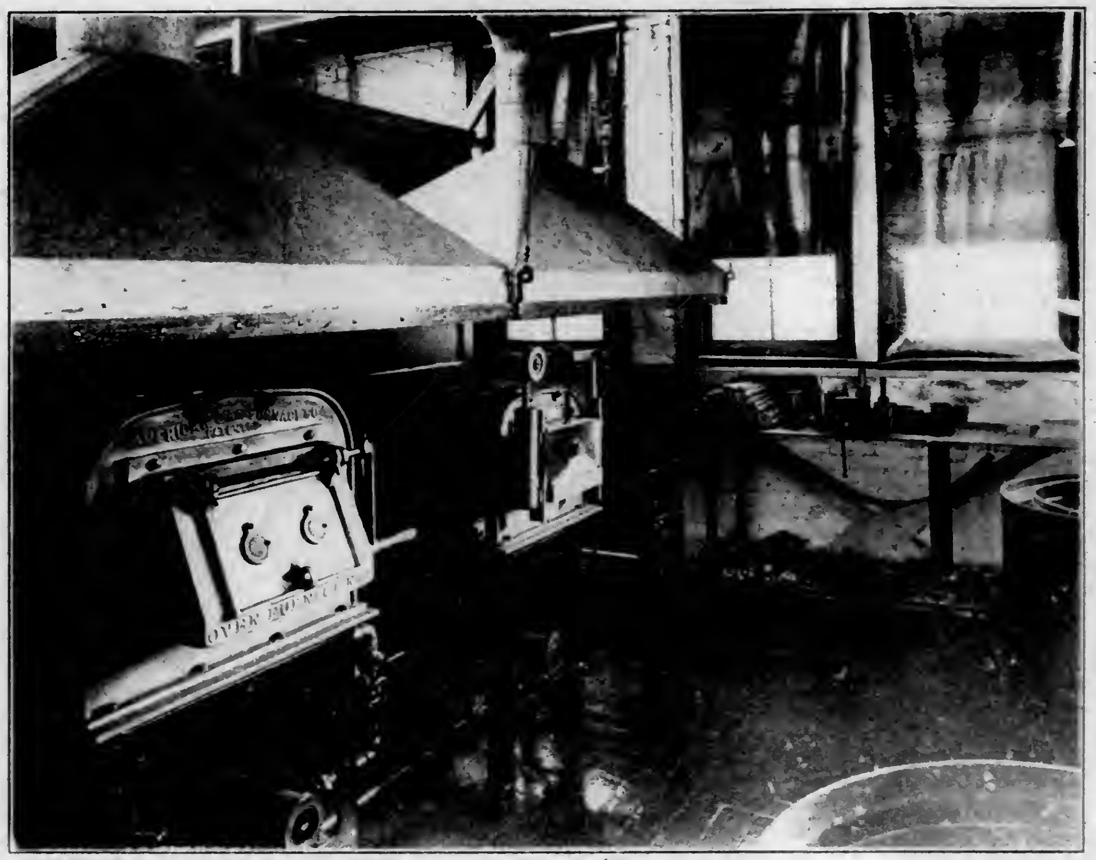


FIG. 11.—TOOL HARDENING ROOM AT TOPEKA SHOPS. HERE ALL THE CUTTING TOOLS MANUFACTURED IN THE TOOL ROOM ARE TEMPERED OR HARDENED.

FIG. 12.—GENERAL STOREHOUSE STOCK OF STANDARD TOOLS MANUFACTURED IN TOOL ROOM AT TOPEKA AND SUBJECT TO REQUISITION FROM ALL OUTLYING SHOPS.

with the rules and regulations of the tool system, and the co-operation which naturally follows has greatly increased the efficiency of tools and tool rooms. The bulletin referred to is as follows:

TOOL REGULATIONS.

Proper and economical work depends upon the tools used, the condition in which they are kept, and their availability for service when needed. System must be used in the care and distribution of tools, so that excessive amounts of them will not be accumulated, and so that expensive tools

(Form 1077 Standard)

STOCK BOOK____________________

Section __________

Catalogue Page____	DESCRIPTION OF ARTICLES	Symbol Number	Units of	JUNE		JULY		AUGUST		SEPTEMBER	
				Inventory	Ordered	On Hand	Ordered	On Hand	Ordered	On Hand	Ordered

FIG. 13.—UPPER PART OF ONE PAGE OF TOOL STOCK BOOK IN WHICH EACH SHOP KEEPS A RECORD OF TOOLS ON HAND AND ON ORDER. RECORDS FROM JUNE TO SEPTEMBER ARE CARRIED ON THIS PAGE AND THE REMAINING EIGHT MONTHS ON PAGE OPPOSITE.

will not be kept idle in one place when they are needed in another; system must be used in the standard design of tools and methods of doing work adopted, so that the work may be properly and economically done.

With these objects in view all decisions as to designs of tools, jigs, special devices, etc., and as to methods of doing work, will be made after reference through the office of Assistant Superintendent Motive Power, at Topeka; all suggestions as to changes in methods and all ideas as to changes in design of tools, devices, etc., or as to new forms of tools or new jigs and devices, must be submitted to that office in duplicate, and receive the approval of the Assistant Superintendent Motive Power, before they can be put into effect or be adopted. This is necessary, as often ideas and methods are developed at considerable expense in one place, when they have been already tried and proven unsatisfactory elsewhere. This useless expense should be avoided. Recommendations may be made either through the regular channels, or directly by the men.

Hall-8-06-10M-2428 (Form 2928 Standard.)

Santa Fe.

IN ALL-CASES WHERE TOOLS ARE LOST, BROKEN OR DAMAGED, THIS CARD MUST BE FILLED OUT.

TOOL BREAKAGE CLEARANCE.

(ONLY ONE TOOL TO EACH CARD.)

No.____________________has
(SHOP LETTER, NUMBER AND NAME.)

Check Here
____ *Worn Out*
____ *Damaged*
____ *Broken*
____ *Lost*

____________________size__________
(GIVE FULL NAME OF TOOL.)

as a result of
____ *Defective Material*
____ *Accident*
____ *Ignorance*
____ *Carelessness*

O. K.

This card must be signed by your Foreman, one of the following:

INITIALS HERE.	DATE
GANG FOREMAN.	
TOOL KEEPER.	
GEN'L TOOL FOREMAN.	
GEN'L FOREMAN.	

FIG. 14.—TOOL BREAKAGE CLEARANCE CARD. WHEN A TOOL IS LOST OR BROKEN, A CLEARANCE CARD PROPERLY SIGNED MUST BE PRESENTED AT THE TOOL ROOM BY WORKMAN TO OBTAIN HIS CHECK ON TOOL.

A system for checking tools out from the tool room, checking them up in the tool room, and inspecting them while out of the tool room, has been developed from the best practice in use at first-class shops, and will be thoroughly installed in all tool rooms on this system.

This tool system will comprise the following features:

A. Perpetual or continuous inventory will be had of all tools, machines, and devices of all sorts at each shop, showing location of tool, whether assigned to tool room stock or to the permanent use of an individual man or gang.

B. Uniform aluminum checks of special design, six to each man, will be furnished from Topeka for each shop, indicating the shop and the block number of the mechanic to whom issued; these checks will only be issued to such men as require to call on the tool room for tools; Topeka will be called on for such checks as are required from time to time, which will be forwarded by railroad mail.

C. Standard tool lockers will be assigned to men using tools as far as practicable.

D. Standard tool kits for each class of occupation will be determined upon and these kits will be supplied to each man when he enters the service, he signing up for same and being held responsible therefor: the man will also be held responsible for the checks issued.

E. A regular weekly inspection system of all tools will be inaugurated as rapidly as it can be organized.

In addition to these general measures the following special regulations will be in force:

1. No tools will be issued from tool room except for tool check.
2. No new hand-hammers or monkey wrenches to be given in exchange for old ones unless accompanied by an order from the gang foreman and marked "OK" by shop foreman; chisels and soft hammers to be the only tools exchanged for new ones without a written order.
3. No letters or figures to be given out in lots of less than a full set.
4. All tools out on check must be turned into the tool room every Saturday night before the tool-keeper leaves the shop. In all cases where tool checks remain on the board over Sunday, the tool-keeper should notify the tool room foreman or the general

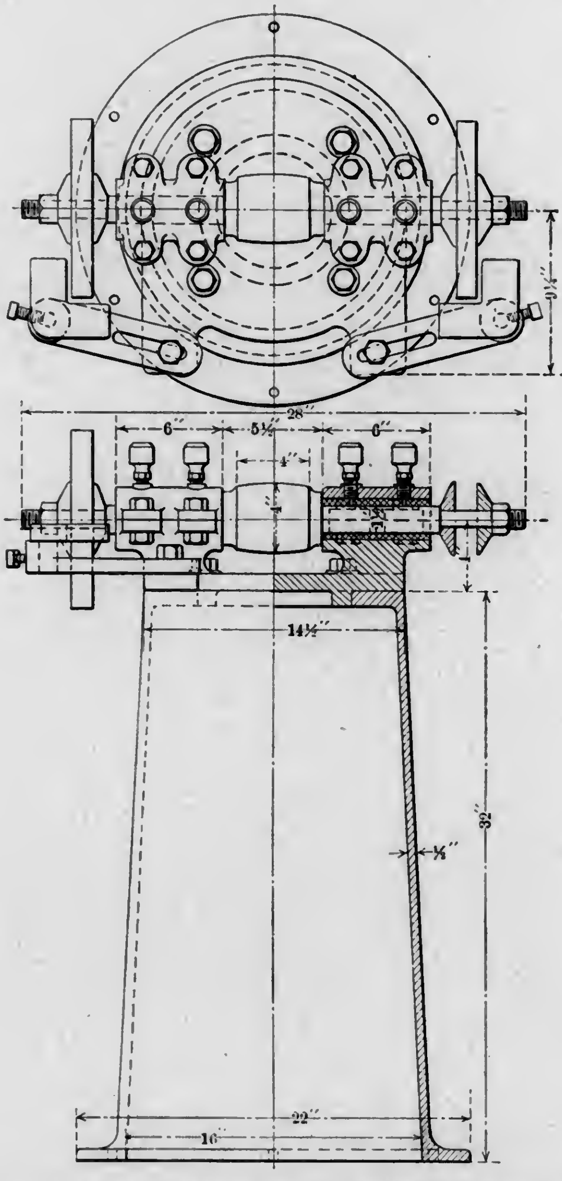


FIG. 10.—STANDARD ABRASIVE WHEEL STANDS FINISHED IN TOOL ROOM AT TOPEKA, AND IN GENERAL USE IN ALL SHOPS ON THE SYSTEM.

foreman, and the men whom these checks belong to should be required to give an explanation for not returning the tools. In some shops it may be desirable to check the tools up daily.

5. In all cases of broken, or lost, or damaged tools the tool check will not be returned until the tool clearance card (Fig. 14) has been personally signed by the general foreman as per circular letter No. 358.
6. In places where, in addition to tools, the tool room is used for a sort of shop sub-store for small engine supplies, such as cutters, small bolts, etc., the gang foreman's orders will be honored for these supplies.
7. The custody of all high speed lathe, planer, and boring mill tools should come under the tool room foreman, or the man in charge of the tool room. A man starting to work on a machine requiring these tools should be given a set and these should be charged to him. Should he break one of these tools, he will exchange it for a new one in the tool room. The tool room foreman or the tool man should get a list of the number of high speed tools, the list showing size and style now at various machines, and the workmen should sign up for them.
8. All air motors must be returned to the tool room every Saturday night and be thoroughly inspected and oiled before leaving the tool room again. At shops like Topeka, Albuquerque, San Bernardino and Cleburne, it may be desirable to assign certain motors to a gang and that this gang be allowed to use these motors during the week, turning them into the tool room on Saturday night for regular inspection. All motors should be numbered and a record kept of what gang they have been assigned to. Where parts of motors are missing, the motors should not be accepted without authority of the tool room foreman. It should be the tool room foreman's duty to see that all motors are regularly inspected and repaired and oiled as often as necessary, which, for motors in service, should be as often as once a week.

While the efficiency of tools and tool rooms is of primary importance, expenditures for expensive tools and devices are not

Form 2033 Standard.

SANTA FE.

....
(Insert name of Railway Company.)

REPAIRS AND RENEWALS TO SHOP MACHINERY AND TOOLS [ACCOUNT 47. (Replacing old Account 17.)] AND CHARGES TO POWER PLANTS, EXCEPT ENGINES, BOILERS AND MACHINERY CHARGEABLE TO OTHER ACCOUNTS.

At...Shops during..190

	Shops.		Renewals Large Machinery in Replacement of Old and charged to Account 47.	Repairs and Renewals to Machinery Appliances, shafting, etc., except as otherwise designated on this form	Making new Tools for use with Machines.	Repairs to Tools for use with Machines, including Dressing	Repairs and Renewals of Power Engines and Boilers in shops, etc.	Repairs and Renewals to Air Line and Air Tools.	Repairs and Renewals of Abrasive Wheels.	Repairs and Renewals of Belts	Repairs to Electrical Machinery, including Cranes.	Other than Foregoing. x	Total.
			0	1	2	3	4	5	6	7	8	9	
47-A	Machine.	11											
47-B	Erecting Shop.	12											
47-C	Boiler Shop.	13											
47-D	Blacksmith Shop	14											
47-E	Tin Shop.	15											
47-F	Brass and Air Room	16											
47-G	Tool Room	17											
47-H	Water Service.	18											
47-I	Pattern Shop.	19											
47-K	Car Machine Shop.	20											
47-L	Loco. Carpenter Shop.	21											
47-M	Wheel and Axle Shop.	22											
47-N	Power Plant.	23											
47-O	Miscellaneous.	24											
	Total..........................												

This account includes repairs:
Cost of material used and labor expended in repairing tools and machinery in engine houses and at locomotive and car shops and foundries:

Column No.
- (4) Including stationary engines and boilers for furnishing power.
- (1) Scaffolding and shafting.
- (7) Belting.
- (1) Other appliances for running machinery, cranes, hoists, power and hand (except electrical), drop tables, jacks and other appliances, used in connection therewith; also in repairing furnaces, forges, hydraulic and other portable jacks.

Portable scales and sewing machines used in shops. Cost of repairing heating boilers should be charged to account 16, "Buildings, Fixtures and Grounds."

Renewals: Cost of new tools: (1, 2 and 5).

Column No.
- (0) Machinery (less salvage) used in engine houses and at locomotive and car shops and foundries.
- (4) Including stationary engines and boilers for furnishing power.
- (1) Scaffolds and shafting.
- (7) Belting.
- (1) Other appliances for running machines.
- (0) Cranes.
- (1) Hoists (power and hand).
- (0) Drop tables.
- (1) Jacks and other appliances used in connection therewith.
- (0) Furnaces and forges.
- (1) Hydraulic and other portable jacks. Portable scales and sewing machines used in shops.

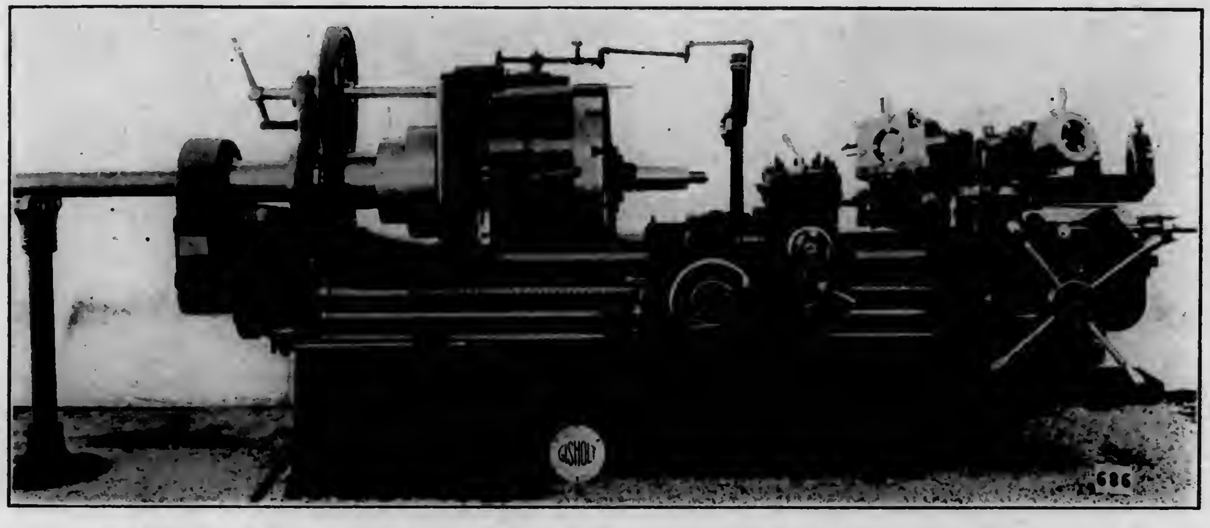
Cost of renewing heating boilers should be charged to Account 16, "Buildings, Fixtures and Grounds."

x NOTE.—Give explanation on separate sheet of each individual item constituting charges in this column.

Date ....Storekeeper ....Motive Power Accountant

FIG. 15.—FORM FOR KEEPING CHARGES OF REPAIRS AND RENEWALS TO SHOP MACHINERY AND TOOLS. THIS FORM IS MADE OUT AT EACH SHOP EVERY MONTH AND SHOWS THE VARIOUS CHARGES TO THE TOOL ACCOUNT.

approved unless there is a direct need for them and the saving in production costs is represented by a satisfactory return on the investment. In order to keep an accurate record of the charges to repairs and renewals to shop machinery and tools, the form shown in Fig. 15 was adopted. The form is arranged with nine columns, each reserved for a different charge account covering repairs and renewals to shop machinery and tools, and charges to power plants. This form is filled in once each month at all shops and forwarded to Topeka. An accurate check and supervision over the tool account is thus obtained and excessive expenditures for tools are eliminated without impairing the efficiency of the tool system.



GISHOLT 24-IN. LATHE WITH 5-IN. HOLE THROUGH THE SPINDLE, EQUIPPED WITH BAR TOOLS FOR MAKING CROSSHEAD PINS.

FINISHING CROSSHEAD PINS FROM BAR STOCK.

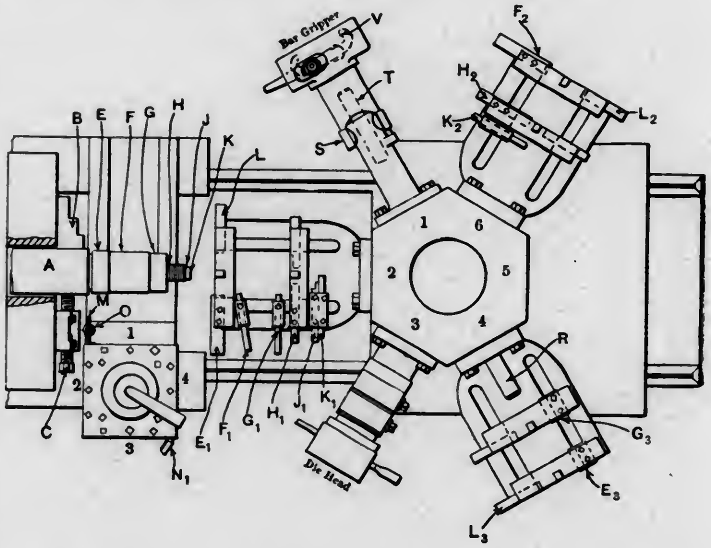
The problem of the economical production of such locomotive repair parts as are put through the shop in comparatively small lots is a troublesome one. The concentration of manufacture at central shops and the standardization of locomotive parts on the larger systems has simplified this problem to some extent, especially in the case of those parts which require frequent renewal. There are, however, many parts which even under the most favorable conditions must be put through the shop in such small lots as not to warrant the use of special machines. This condition makes desirable a machine designed for a wide range of work, which can easily and quickly be adapted to rapidly and accurately finish different parts.

The Gisholt Machine Company, Madison, Wis., started a number of years ago to develop a lathe to meet this condition. The result was a combination bar and chucking lathe; if there is not a sufficient amount of bar work to keep the machine busy it requires only a change of tools to produce chuck work. Such a machine is adapted for finishing liners, brasses, pistons, piston centers, front and back cylinder heads, piston followers, bull rings, eccentrics, eccentric straps, crossheads, pipe flanges, steam chest covers and work off the bar, such as crosshead pins, valve motion pins, brake hanger pins, etc. It has been found that in many cases these parts can be finished in lots of as few as six or eight with a saving of from 50 to 80 per cent., and upwards, over former methods.

In the case of the pins which are made from bar stock, the expense of making forgings is done away with, and, because of the manner in which the work is chucked, no time is lost in centering it in the machine. In some shops such parts as knuckle and crosshead pins are finished complete except the tapered surfaces, which are left a little large and are finished to the required size as they are needed. To give a general idea of the way in which such pins are finished from the bar the following description of the finishing of a crosshead pin on a Gisholt Big Bore lathe, with a 5-in. spindle bore, is given. The piece of bar stock, A, is held in the three-jawed scroll chuck by hard chuck jaws, B, and also by three chuck blocks, C.

The first operation consists in removing the greater part of the surplus stock, bringing the pin approximately to size. This roughing operation is completed by the cutters shown in the box tool attached to face 2 of the main turret, the cutters E-1, F-1, G-1, H-1, J-1 and K-1 removing the stock on the surfaces indicated by the corresponding letters on the piece itself. Just before starting this roughing head the tool post tool, N, is used for truing up the end of the bar.

The next operation consists in bringing surfaces F and H to exact size. This is done with cutters F-2 and H-2 in the box tool on face 6 of the main turret. Cutter K-2 faces the end K of the piece and at the same time gauges the length of the pin: L-2 acts as a back rest for supporting the pin.



The box tool on face 4 of the main turret is then swung into position and the cutters G-3 and E-3 bring surfaces E and G to correct size and taper; the arbor R is arranged as a gauge to determine the proper location of the tapered surfaces, thus insuring duplicate work when cutters E-3 and G-3 are once properly set; L-3 is a back rest.

All surfaces on the pin having been brought to size, the next operation consists in cutting the thread, which is done with the die head on face 3 of the main turret. This completes the piece; the tool post cutting off tool M supported by post O is then used for cutting off the finished pin.

SHOWING BORE TOOL AT WORK ON CROSSHEAD PIN ON GISHOLT BIG BORE LATHE.

After the piece has been cut off the jaws and blocks are loosened and the bar gripper shown on face 1 of the main turret is swung into position. This bar gripper consists of a pair of self-acting jaws, V, for gripping the piece and drawing it out, and an arbor, T, for pushing the piece back to the proper position. The operation is as follows: Through a rapid traversing device the bar gripper is brought rapidly to the piece and the self-acting jaws, V, grip the stock firmly; then, by operating the turret rapid traversing device, the bar is drawn out to approximately the proper length. The jaws V are released and the forward half of the bar gripper is swung upwards at right angles on the hinge S, thus exposing the arbor T, which is used to push the piece back, leaving the proper length of stock projecting.

50-TON ALL-STEEL DROP-BOTTOM GONDOLA CAR.

CHICAGO, BURLINGTON & QUINCY RAILROAD.

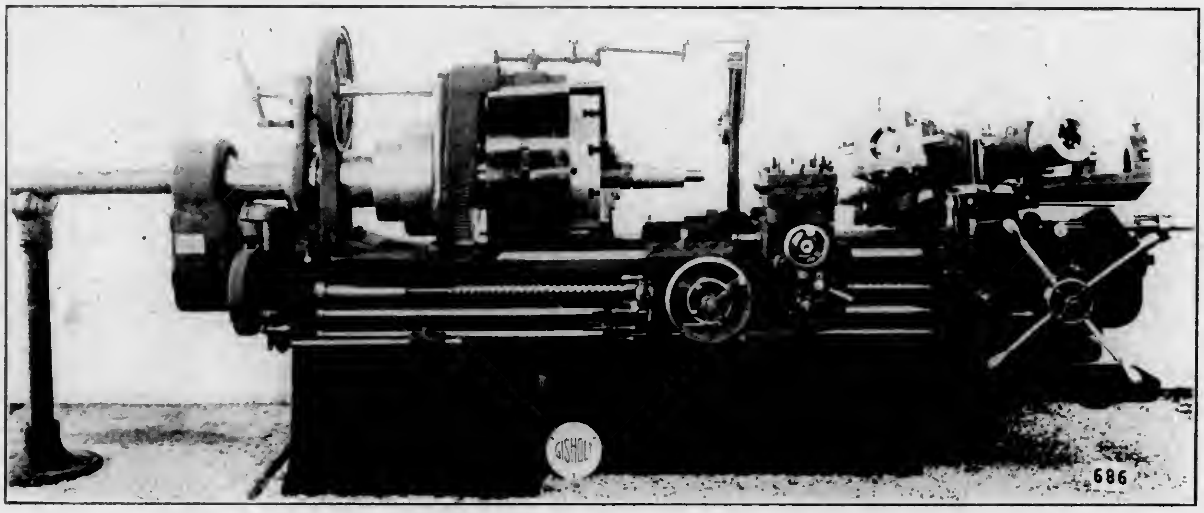
The Chicago, Burlington & Quincy Railroad has recently received one thousand 100,000 lb. capacity all-steel drop-bottom gondola cars, which were built by the Bettendorf Axle Co., Davenport, Ia. These cars are of a light but exceedingly strong type of construction and possess several novel features of design. It is an unusually open type, as may be seen from the illustrations, making inspection easy; a large proportion of the different members are of standard rolled sections, which may be purchased upon the open market and are easily applied. Instead of stiffening the tops of the side and end sheets by riveting on angles, or other commercial sections, the tops of the sheets are rolled into tubes of 2¼ in. inside diameter. The end sheet has a heavier top roll and in addition is stiffened by heavy corrugations.

The car is carefully designed to allow the side girders and center sill to carry their respective loads and yet unify the carrying power of all of the parts, resulting in a design in which no one part is unduly stressed and abnormal sections are not required. The inside dimensions are as follows: 40 ft. long; 9 ft. 6 in. wide, and 51 in. deep. The side sheet is of ¼ in. steel with a wide sloping flange at the bottom, which does not, however, pocket any material when the car is dumped. Each side is formed by two sheets spliced at the center of the car by a side stake and a heavy splice plate. The side is stiffened by seven pressed steel stakes, each stake being riveted to the end of the cross sill for a length of 10 in., thus making a strong construction to resist side thrusts.

The end sheets are made with a deep, heavy, top roll and are ~~flanged at the corners for connection to the side sheets~~. These sheets are also stiffened by a heavy star-shaped corrugation. They are of ¼ in. steel which is cold shaped during the different operations. The end sill is a 10 in. channel, the top flange of which is bent upward and is riveted to the end sheet; the web is shaped into a long, straight corrugation across the car; poling

50-TON ALL-STEEL GONDOLA CAR—CHICAGO, BURLINGTON & QUINCY RAILROAD.

approved unless there is a direct need for them and the saving in production costs is represented by a satisfactory return on the investment. In order to keep an accurate record of the charges to repairs and renewals to shop machinery and tools, the form shown in Fig. 15 was adopted. The form is arranged with nine columns, each reserved for a different charge account covering repairs and renewals to shop machinery and tools, and charges to power plants. This form is filled in once each month at all shops and forwarded to Topeka. An accurate check and supervision over the tool account is thus obtained and excessive expenditures for tools are eliminated without impairing the efficiency of the tool system.



GISHOLT 24-IN. LATHE WITH 5-IN. HOLE THROUGH THE SPINDLE, EQUIPPED WITH BAR TOOLS FOR MAKING CROSSHEAD PINS.

FINISHING CROSSHEAD PINS FROM BAR STOCK.

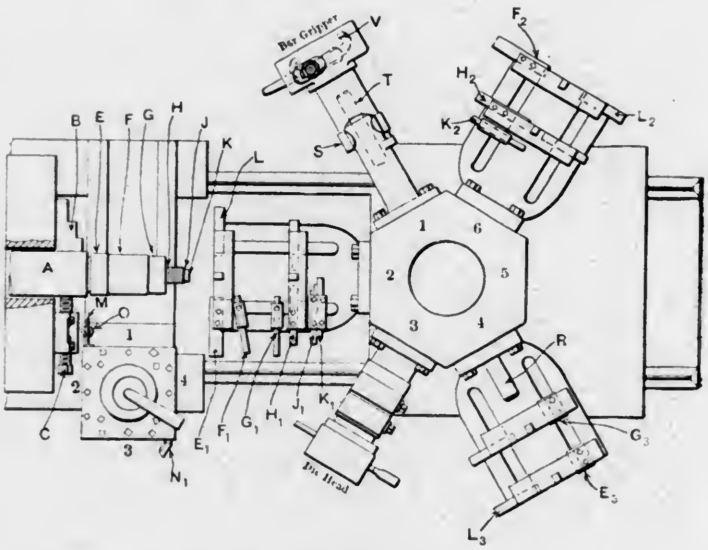
The problem of the economical production of such locomotive repair parts as are put through the shop in comparatively small lots is a troublesome one. The concentration of manufacture at central shops and the standardization of locomotive parts on the larger systems has simplified this problem to some extent, especially in the case of those parts which require frequent renewal. There are, however, many parts which even under the most favorable conditions must be put through the shop in such small lots as not to warrant the use of special machines. This condition makes desirable a machine designed for a wide range of work, which can easily and quickly be adapted to rapidly and accurately finish different parts.

The Gisholt Machine Company, Madison, Wis., started a number of years ago to develop a lathe to meet this condition. The result was a combination bar and chucking lathe; if there is not a sufficient amount of bar work to keep the machine busy it requires only a change of tools to produce chuck work. Such a machine is adapted for finishing liners, brasses, pistons, piston centers, front and back cylinder heads, piston followers, bull rings, eccentrics, eccentric straps, crossheads, pipe flanges, steam chest covers and work off the bar, such as crosshead pins, valve motion pins, brake hanger pins, etc. It has been found that in many cases these parts can be finished in lots of as few as six or eight with a saving of from 50 to 80 per cent., and upwards, over former methods.

In the case of the pins which are made from bar stock, the expense of making forgings is done away with, and, because of the manner in which the work is chucked, no time is lost in centering it in the machine. In some shops such parts as knuckle and crosshead pins are finished complete except the tapered surfaces, which are left a little large and are finished to the required size as they are needed. To give a general idea of the way in which such pins are finished from the bar the following description of the finishing of a crosshead pin on a Gisholt Big Bore lathe, with a 5-in. spindle bore, is given. The piece of bar stock, A, is held in the three jawed scroll chuck by hard chuck jaws, B, and also by three chuck blocks, C.

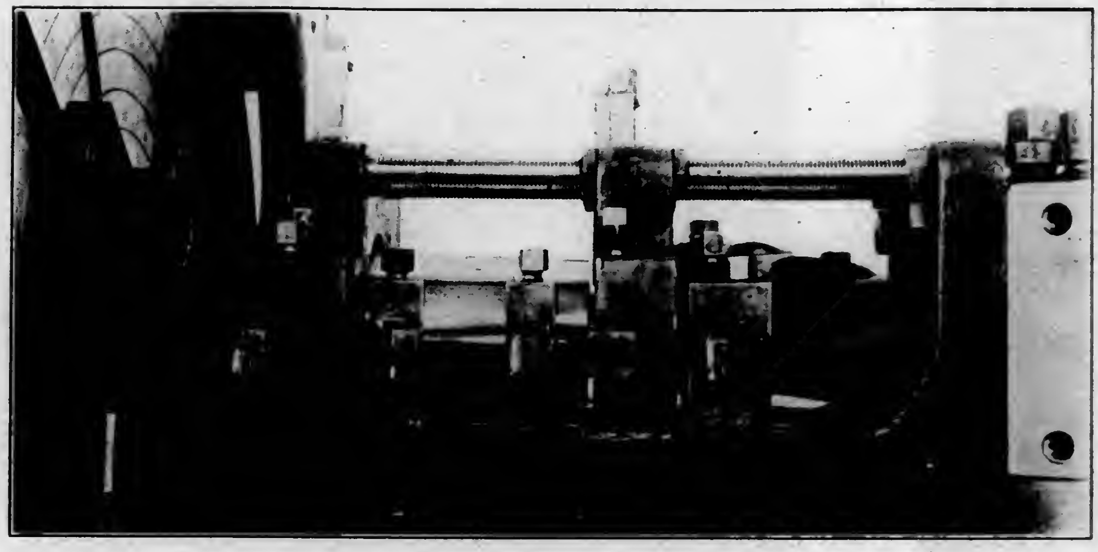
The first operation consists in removing the greater part of the surplus stock, bringing the pin approximately to size. This roughing operation is completed by the cutters shown in the box tool attached to face 2 of the main turret, the cutters E-1, F-1, G-1, H-1, J-1 and K-1 removing the stock on the surfaces indicated by the corresponding letters on the piece itself. Just before starting this roughing head the tool post tool, N, is used for truing up the end of the bar.

The next operation consists in bringing surfaces F and H to exact size. This is done with cutters F-2 and H-2 in the box tool on face 6 of the main turret. Cutter K-2 faces the end K of the piece and at the same time gauges the length of the pin; L-2 acts as a back rest for supporting the pin.



The box tool on face 4 of the main turret is then swung into position and the cutters G-3 and E-3 bring surfaces E and G to correct size and taper; the arbor R is arranged as a gauge to determine the proper location of the tapered surfaces, thus insuring duplicate work when cutters E-3 and G-3 are once properly set; L-3 is a back rest.

All surfaces on the pin having been brought to size, the next operation consists in cutting the thread, which is done with the die head on face 3 of the main turret. This completes the piece; the tool post cutting off tool M supported by post O is then used for cutting off the finished pin.



SHOWING BORE TOOL AT WORK ON CROSSHEAD PIN ON GISHOLT BIG BORE LATHE.

After the piece has been cut off the jaws and blocks are loosened and the bar gripper shown on face 1 of the main turret is swung into position. This bar gripper consists of a pair of self-acting jaws, V, for gripping the piece and drawing it out, and an arbor, T, for pushing the piece back to the proper position. The operation is as follows: Through a rapid traversing device the bar gripper is brought rapidly to the piece and the self-acting jaws, V, grip the stock firmly; then, by operating the turret rapid traversing device, the bar is drawn out to approximately the proper length. The jaws V are released and the forward half of the bar gripper is swung upwards at right angles on the hinge S, thus exposing the arbor T, which is used to push the piece back, leaving the proper length of stock projecting.

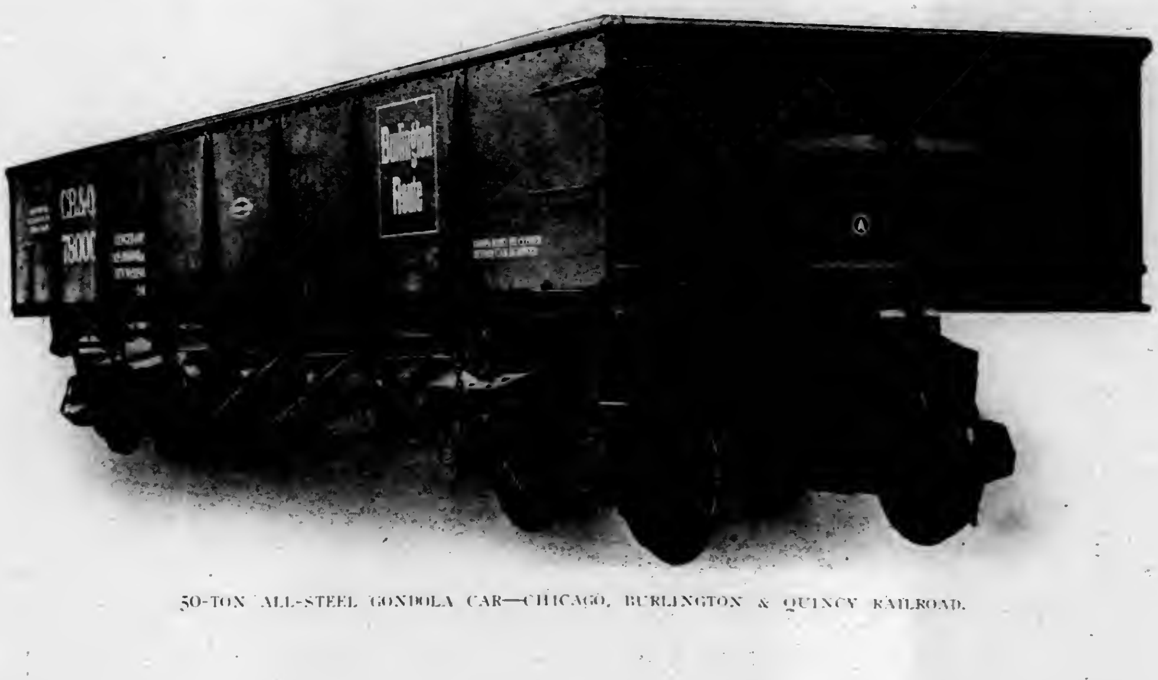
50-TON ALL-STEEL DROP-BOTTOM GONDOLA CAR.

CHICAGO, BURLINGTON & QUINCY RAILROAD.

The Chicago, Burlington & Quincy Railroad has recently received one thousand 100,000 lb. capacity all-steel drop-bottom gondola cars, which were built by the Bettendorf Axle Co., Davenport, Ia. These cars are of a light but exceedingly strong type of construction and possess several novel features of design. It is an unusually open type, as may be seen from the illustrations, making inspection easy; a large proportion of the different members are of standard rolled sections, which may be purchased upon the open market and are easily applied. Instead of stiffening the tops of the side and end sheets by riveting on angles, or other commercial sections, the tops of the sheets are rolled into tubes of 2¼ in. inside diameter. The end sheet has a heavier top roll and in addition is stiffened by heavy corrugations.

The car is carefully designed to allow the side girders and center sill to carry their respective loads and yet unify the carrying power of all of the parts, resulting in a design in which no one part is unduly stressed and abnormal sections are not required. The inside dimensions are as follows: 40 ft. long; 9 ft. 6 in. wide, and 51 in. deep. The side sheet is of ¼ in. steel with a wide sloping flange at the bottom, which does not, however, pocket any material when the car is dumped. Each side is formed by two sheets spliced at the center of the car by a side stake and a heavy splice plate. The side is stiffened by seven pressed steel stakes, each stake being riveted to the end of the cross sill for a length of 10 in., thus making a strong construction to resist side thrusts.

The end sheets are made with a deep, heavy, top roll and are flanged at the corners for connection to the side sheets. These sheets are also stiffened by a heavy star-shaped corrugation. They are of ¼ in. steel which is cold shaped during the different operations. The end sill is a 10 in. channel, the top flange of which is bent upward and is riveted to the end sheet; the web is shaped into a long, straight corrugation across the car; poling

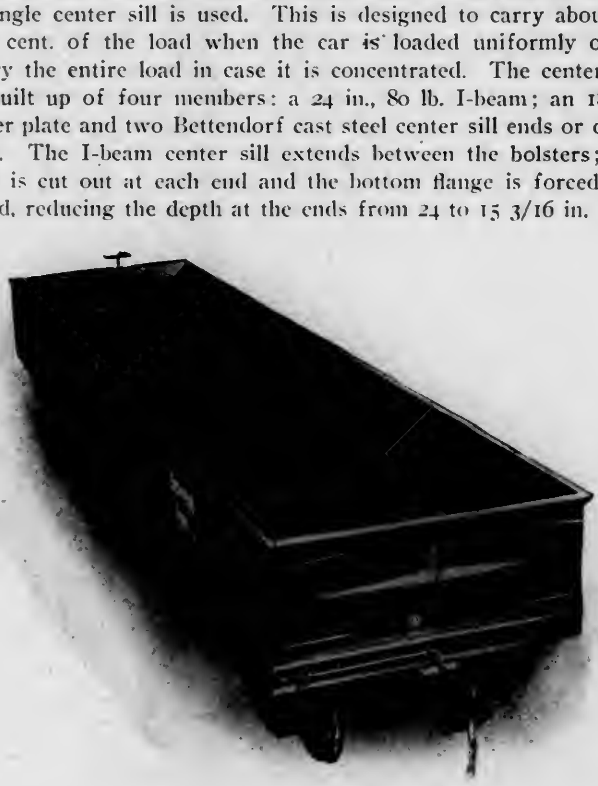


50-TON ALL-STEEL GONDOLA CAR—CHICAGO, BURLINGTON & QUINCY RAILROAD.

BOTTOM VIEW OF BURLINGTON DROP-BOTTOM GONDOLA CAR.

pockets are pressed into the channel web. The end sill is cold shaped in one operation, the severity of the treatment given it assuring only the best grade of open hearth steel being used.

The most radical departure from other designs is that only a single center sill is used. This is designed to carry about 58 per cent. of the load when the car is loaded uniformly or to carry the entire load in case it is concentrated. The center sill is built up of four members: a 24 in., 80 lb. I-beam; an 18 in. cover plate and two Bettendorf cast steel center sill ends or draft sills. The I-beam center sill extends between the bolsters; the web is cut out at each end and the bottom flange is forced upward, reducing the depth at the ends from 24 to 15 3/16 in. The



Bettendorf center sill ends are of cast steel with draft lugs cast integral and are arranged for Miner tandem draft gear, although they may be designed to accommodate any draft gear desired. The center sill ends extend from the striking plate to back of the body bolsters where they are securely riveted to the center sill I-beam. The body bolster is continuous and passes through the center sill ends and is securely riveted to them, both top and bottom. The cover plate extends the entire length of the car. The drop door hinge butts are riveted to the cover plate and the web of the center sill. Permanent floor plates of 5/16 in. steel extend from the body bolster to the end sill, and are riveted to tom flange of the side sheets.

Five 10 in. I-beams and two Bettendorf body bolsters constitute the cross sills. Each cross sill is made strong enough to transmit its load to the center sill, and is continuous from side to side of the car. The top flange of the I-beam cross sill is pressed down at the center, thus allowing it to come flush with the floor level without making a cut in the top flange of the center sill.

The load is dumped by means of 12 drop-doors, operated by winding chains and a 2¼ in. diameter shaft. The doors are made of 5/16 in. steel, flanged and secured to the center sills by malleable iron hinges. Steel hangers, riveted to the needle-beams, catch the doors and remove the strain from the winding chains when the load is dumped. The dumping mechanism is of the creeping shaft type and is protected from injury by the bottom flange of the side sheets.

The trucks are the Bettendorf standard, cast steel, side frame, 50 ton type. The journal boxes are cast integral with the side frames, and the arch bars, columns, bolts, etc., are dispensed with. The cast steel side frame reduces the weight of trucks about 1,000 lbs. per car and eliminates nearly 200 pieces per set of trucks. The light weight of the car is 37,800 lb.; the trucks weigh 14,260 lb. The light weight is said to run to about 2,000 to 3,000 pounds lighter than the usual car of like dimensions.

The fact that there are but a few hot pressed shapes facilitates repairs at small division points. The construction of the center sill gives it power to resist high buffing strains and the method of design and distribution of stresses should enable the car to withstand the severest kind of service.

Our National Problem.—Finally, let us remember that the conservation of our natural resources, though the gravest problem of to-day, is yet but part of another and greater problem to which this nation is not yet awake, but to which it will awake in time, and with which it must hereafter grapple if it is to live —the problem of national efficiency, the patriotic duty of insuring the safety and continuance of the nation. When the people of the United States consciously undertake to raise themselves as citizens and the nation and the States in their several spheres to the highest pitch of excellence in private, State and national life, and to do this because it is the first of all the duties of true patriotism, then and not till then the future of this nation, in quality and in time, will be assured.—*President Roosevelt, at the Governors' Conference.*

DEVELOPMENT OF THE MUFFLED POP SAFETY VALVE.

The muffled pop safety valve for locomotives has, like other perfected locomotive appliances, reached its present state of excellence through a long period of development and improvement. The history of this type of valve dates back over twenty years, previous to which time it was not considered possible to muffle the sound from an escaping pop valve.

The first muffler applied by the American Steam Gauge & Valve Mfg. Co., who were among the pioneers in introducing

this improvement, is shown in Fig. 1. It consisted of an extra attachment which could be applied to any safety valve and included a brass casing completely enclosing the valve and open at the top. The outlet for the steam was obstructed by two mufflers, each consisting of three concentric rings of coiled wire held between a couple of perforated plates. These two layers were placd a short distance apart, so that the complete effect of each could be obtained.

The muffled pop valve soon became very popular and Fig. 2 shows a combined pop valve and muffler which was built by the same company about 1896. As can be seen from the illustration, the muffling section follows the early plan of having rings of coiled wire held between perforated plates through which the outgoing steam must pass. In this case, however, there is but one section. The valve itself is a considerable improvement over the earlier pop valves and includes a regulating ring which can be adjusted from the top of the valve by removing the muffler casing. The compression of the spring is also adjustable from the same point. It will be noticed that it was not considered necessary at that time to enclose the spring and it is exposed to the full passage of the outgoing steam. The wings on the bottom of the valve itself are depended upon to keep it central and the valve seat is very light compared to the present valves.

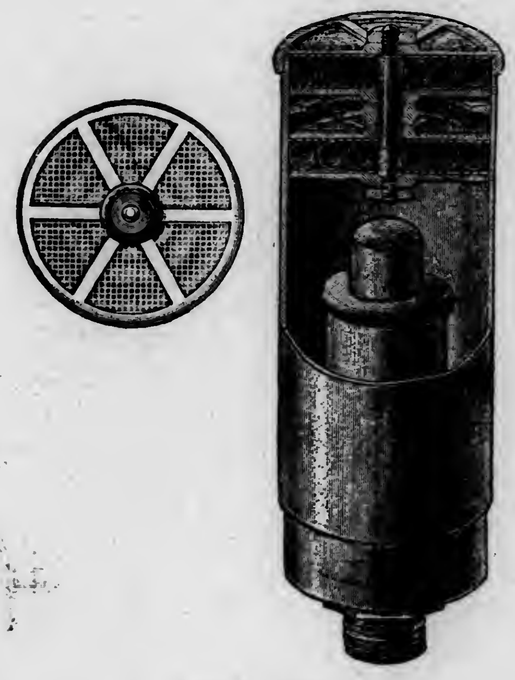


FIG. 1—1887.

This design was followed a few years later by the one shown in Fig. 3, which illustrates a big step in the development. In this valve we find the spring entirely enclosed, the valve equipped with guides both above and below, the size of the valve seat increased, and an entirely new system of muffling introduced. The same arrangement of regulating ring, which is adjustable for the top of the valve, that was used on the earlier design, has been retained. The mufflers instead of being at the top have been placed at the sides and are of an entirely new design, consisting of a large number of concentric brass rings arranged in three sections, one above the other. A full adjustment of any part of the valve can be made by removing a small top cap. This valve represents the starting point of all the later muffled pop valves of this company.

The next step is shown in Fig, 4 and consists principally of minor improvements over the previous valve. This was brought out about 1901. In it the spring has been made longer, an extra set of muffling rings has been introduced, the regulating ring has been made broader and stiffer and the spring is copper plated. In other respects, however, it differs only in heavier construction, giving increased strength and durability.

The next step in improvement of pop valves by this company is shown in Fig. 5, which illustrates a design of 3½ in. valve

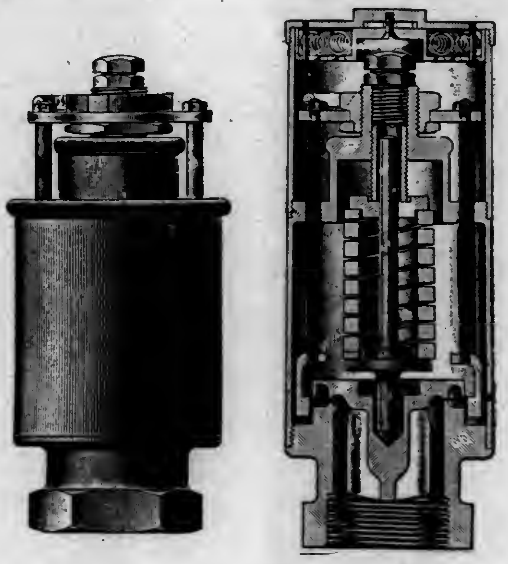


FIG. 2—1896.

brought out last year. This valve is almost as large an improvement over its immediate predecessor as was No. 3 over its predecessor. The most noticeable feature is probably the binding of the muffling rings together with phosphor bronze bolts and holding the series in place with a ring threaded on the spring casing which, after being tightened, is locked into place. The regulating ring has been greatly strengthened by being made broader and thicker and the same advantageous method of adjusting from the top of the valve which was used from the beginning has been retained. A new method of arranging the guide above the valve has been introduced, which removes all possibility of any back pressure coming on to the top of the valve. It consists of a separate guide or ring secured to the spring casing and extending outward and downward around the outer edge of the valve. This in connection with an increased length of wings below the valve removes all possibility of the valve cocking on its seat. The binding of the muffling rings together by bolts, which, as can be seen in the illustration, is done by increasing the depth of the supporting rib so that it rests on top of the lower ring, greatly reduces the vibration effect on the whole valve which in the earlier designs tended to gradually loosen all of the parts. The use of a phosphor bronze bolt permits the rings to be drawn up so securely that there is practically no chance of them becoming loosened. The two bolts carrying the regulating ring are also made of phosphor bronze. The remainder of the valve is made of the highest grade brass,

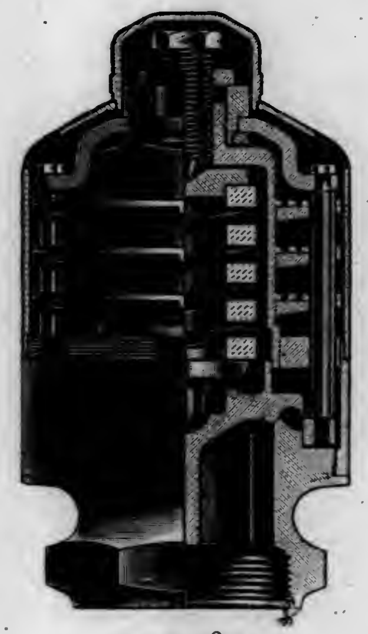


FIG. 3—1899.

FIG. 4—1901.

the valve seat being very liberal in area and of very hard material. The spring is copper plated as in the previous valve. The adjustment of all parts is concentrated at the upper point, which is covered by a small cap. The removal of this permits the setting of the valve and the adjustment of the regulating ring.

The latest design of muffled pop valve, which has been perfected by this company during the last few months, is shown in Fig. 6. It will be noticed that some radical changes have been made, particularly in the muffling device, which instead of being a separate series of rings is, in this case, an inclined series of narrow rings, forming part of the inner casing. This change

FIG. 5—1907.

has been made with the idea of giving a freer discharge, thus reducing the back pressure in the valve chamber, and also entirely eliminating any possibility of these rings becoming loosened. The upper guide, for the valve proper, has been improved over the former design by also making it a part of the inner casting instead of a separate section.

The style of the huddling chamber and the form of relief have been entirely changed, the latter now consisting of a series of holes which terminate in a groove, the arrangement of which is shown in the illustration. The regulating ring operates by restricting the discharge through this groove instead of at the edge of the valve proper, as has previously been the case. The regulating ring itself has also been altered, being made heavier

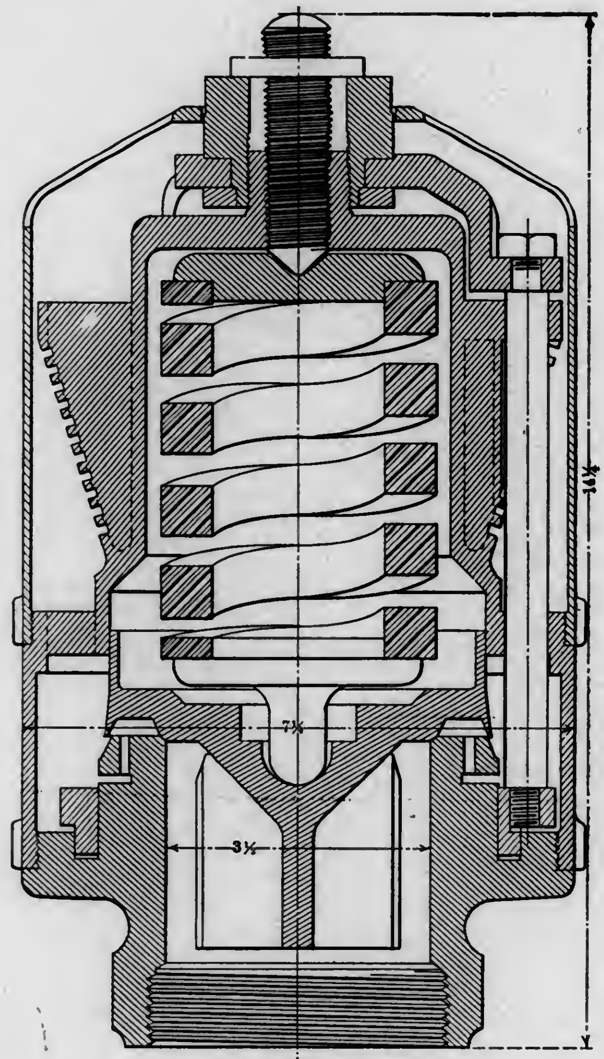


FIG. 6—1908.

and arranged with a bearing in the valve base, which, in addition to the provision for three supporting rods instead of two, will insure an even lift and prevent any possible chance of vibration.

The cap inclosing the top of the valve has been eliminated in this design and adjustment for the popping point and closing point can be made directly from the top of the valve without removing or opening any part.

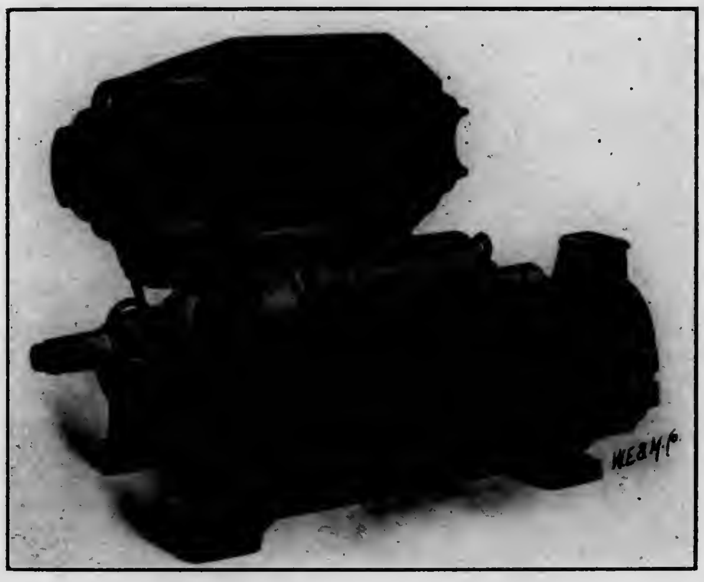
Loss of Fuel on Locomotives.—Approximately 20 per cent. of the coal supplied locomotives is used in starting fires, in keeping the machine hot while standing on side tracks, or is left in the firebox at the end of the run. Sixteen million tons of the annual consumption are thus accounted for. From 8 to 10 per cent. of the remainder is discharged as unconsumed fuel from the stack during the operation of the locomotive and the remainder is required for the generation of steam.—*Dr. W. F. M. Goss before the Amer. Soc. Mech. Engrs.*

MOTOR FOR DRIVING TRANSFER TABLES AND BENDING ROLLS.

The "mill type" direct current motor which has recently been placed on the market by the Westinghouse Company is adapted to certain classes of railroad work, such as operating transfer tables and driving bending rolls in the boiler shop. It has been carefully designed to meet the severe conditions in steel mills, and has given very satisfactory results in that service.

When used on a transfer table it may be provided with two friction clutches, one operating the drum for pulling cars or dead engines on or off the table, the other operating the driving mechanism of the table. As it is possible to disconnect both clutches at the same time, there may be times when there is no load on the motor, and an ordinary series motor would run at a speed sufficient to cause damage to itself. This motor, however, has a shunt field connection, which limits the no load speed to approximately double the full load speed.

The illustration shows the motor opened for removal of the armature. The motor frame is divided horizontally and is hinged, allowing the upper half to be quickly swung back for re-



"MILL TYPE" DIRECT CURRENT MOTOR.

pairs. The heavy section of the frame insures freedom from vibration. The frame is provided with handholes for inspection of the commutator and windings, but the covers fit tightly and the frame is dustproof. The bearing housing is extended beyond the bearing and a dustproof construction is secured by means of a steel washer and felt lining.

The dimensions of the shaft are exceptionally large, with keyways of liberal dimensions, and all chance of bending and breaking is eliminated. A noticeable feature of the bearings is their large wearing surface, insuring long life. The air gap between the fields and the armature is large, and allows considerable wear in the bearings before the revolving and stationary parts can come in contact. Special provision has been made for preventing oil from being drawn into the armature or creeping along the shaft. The bearings are split and made interchangeable for either end of the motor. No dowel pins are used, as lugs cast on the bearings keep them from turning. An eye bolt on each bearing permits ready handling of the armature.

The insulation used on the motors is incombustible throughout, and withstands very high operating temperature without deterioration. The coils are treated with the insulating compound and then baked at a temperature far higher than any that will ever be met in actual service. The carbon holder is of substantial design, and so constructed that by the removal of one holding bolt the entire holder, as one piece, can be removed from the motor. The insulation is thoroughly protected from moisture and mechanical injury.

The armatures are wound with strap copper insulated with mica tape, handwound. This form of coil can be easily repaired, which is not possible with wire wound coils, which are useless if the insulation becomes badly damaged. The coils are held in place by hard fibre wedges and bands which are below the surface of the laminations.

A Correction.—Through an error the Bridgeford 42-inch geared head engine lathe, described on page 191 of the May issue, was mentioned as a Bridgeport lathe. These machines are made by the Bridgeford Machine Tool Works, Rochester, N. Y.

PERSONALS.

N. L. Smitham, master mechanic of the Texas Midland R. R., has resigned.

A. C. Miller has been appointed to succeed N. L. Smitham as master mechanic of the Texas Midland R. R.

C. A Deweese, master mechanic of the Denver & Rio Grande Ry. at Helper, Utah, has resigned.

H. C. Eich, master mechanic of the Illinois Central R. R. at East St. Louis, has been transferred to Paducah, Ky., succeeding J. H. Nash.

J. H. Nash, master mechanic of the Illinois Central R. R., has been transferred from Paducah, Ky., to Waterloo, Ia., succeeding R. W. Bell, promoted.

A. Williamson, mechanical inspector, and F. J. Lass, mechanical engineer, of the Mexican Central Ry. at Aguascalientes, Mex., have exchanged positions.

W. C. Whittaker, formerly of Burnham, near Denver, Colo., has been transferred to Helper, Utah, as master mechanic, succeeding C. A. Deweese, resigned.

J. G. Neuffer, assistant superintendent of machinery of the Illinois Central R. R., has been appointed superintendent of machinery, succeeding Mr. Renshaw, resigned.

R. W. Bell, master mechanic of the Illinois Central R. R. at Waterloo, Iowa, has been appointed assistant superintendent of machinery, with office at Chicago, succeeding J. G. Neuffer, promoted.

A. S. Barrows, chief motive power clerk of the Chicago, Rock Island & Pacific Ry., has resigned to accept a similar position with the Delaware, Lackawanna & Western R. R., with office at Scranton, Pa.

W. Cockfield, locomotive superintendent of the Mexican Railway, at Orizaba, Ver., has resigned to accept the position of chief locomotive superintendent of the Peruvian Corporation, with headquarters at Lima, Peru.

H. O. Keay has been elected head of the department of railways at McGill University, Montreal, to succeed Clarence Morgan, who has resigned to re-enter active railroad work. The railway department, which was organized a year or two ago, has become firmly established and organized.

Orlando Stewart, formerly superintendent of motive power of the Bangor & Aroostook Ry., died at his home in Brighton, Mass., on the 27th of April, aged 74 years. Mr. Stewart retired from railroad work last fall and has been in failing health for some time. He is mourned by a wide circle of friends and his death removes a veteran railroader from the ranks.

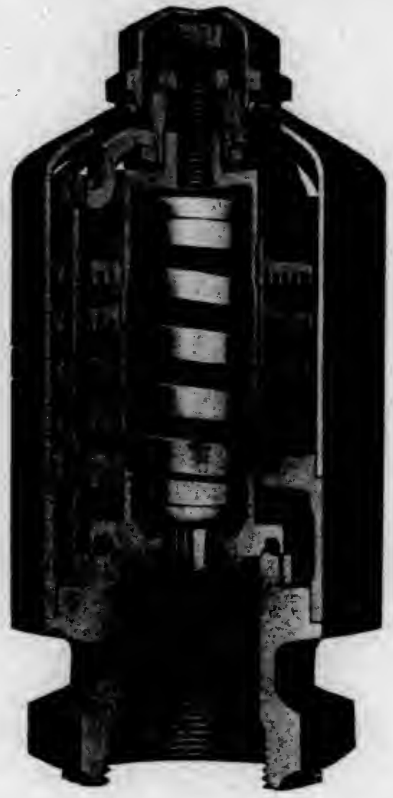


FIG. 4—1901.

the valve seat being very liberal in area and of very hard material. The spring is copper plated as in the previous valve. The adjustment of all parts is concentrated at the upper point, which is covered by a small cap. The removal of this permits the setting of the valve and the adjustment of the regulating ring.

The latest design of muffled pop valve, which has been perfected by this company during the last few months, is shown in Fig. 6. It will be noticed that some radical changes have been made, particularly in the muffling device, which instead of being a separate series of rings is, in this case, an inclined series of narrow rings, forming part of the inner casing. This change has been made with the idea of giving a freer discharge, thus reducing the back pressure in the valve chamber, and also entirely eliminating any possibility of these rings becoming loosened. The upper guide, for the valve proper, has been improved over the former design by also making it a part of the inner casting instead of a separate section.

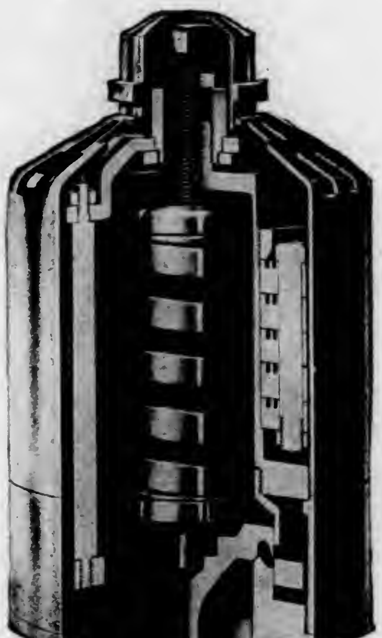


FIG. 5—1907.

The style of the huddling chamber and the form of relief have been entirely changed, the latter now consisting of a series of holes which terminate in a groove, the arrangement of which is shown in the illustration. The regulating ring operates by restricting the discharge through this groove instead of at the edge of the valve proper, as has previously been the case. The regulating ring itself has also been altered, being made heavier

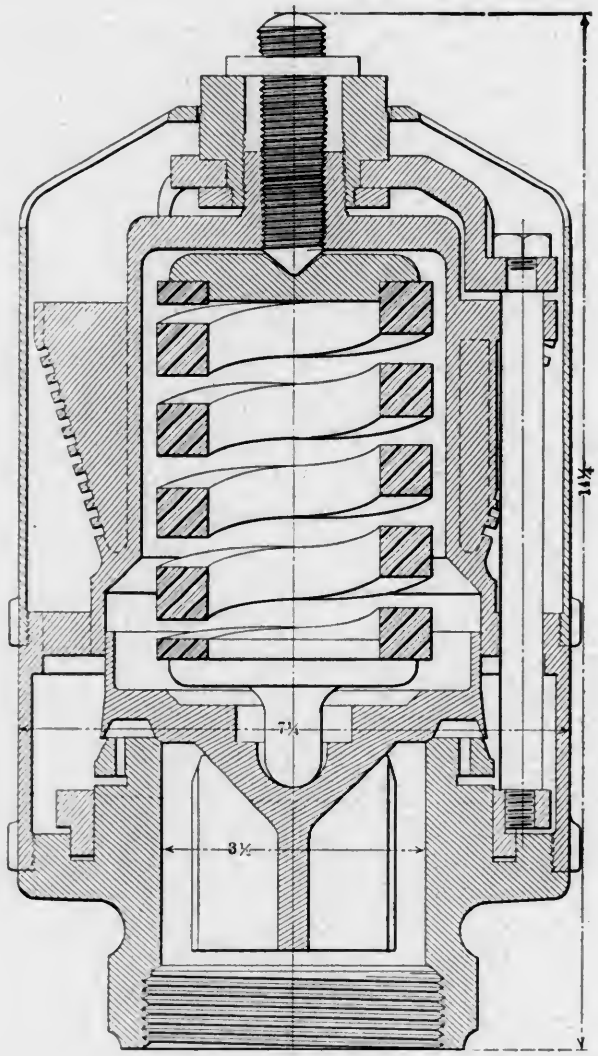


FIG. 6—1908.

and arranged with a bearing in the valve base, which, in addition to the provision for three supporting rods instead of two, will insure an even lift and prevent any possible chance of vibration.

The cap inclosing the top of the valve has been eliminated in this design and adjustment for the popping point and closing point can be made directly from the top of the valve without removing or opening any part.

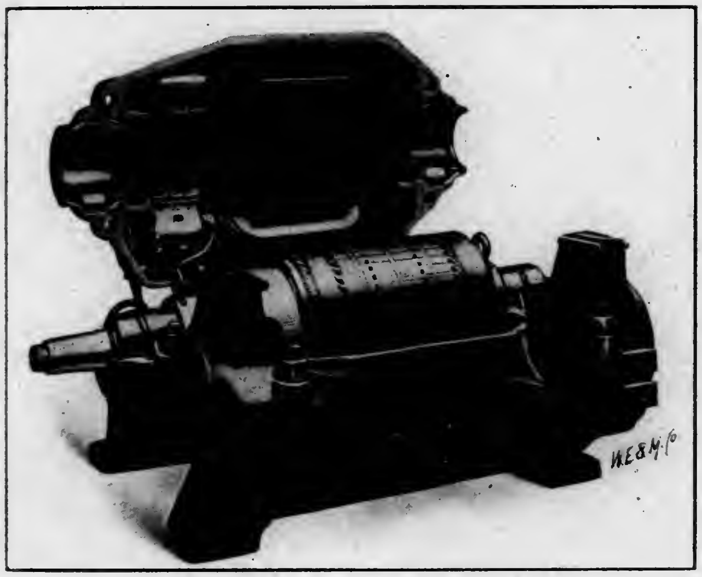
LOSS OF FUEL ON LOCOMOTIVES.—Approximately 20 per cent. of the coal supplied locomotives is used in starting fires, in keeping the machine hot while standing on side tracks, or is left in the firebox at the end of the run. Sixteen million tons of the annual consumption are thus accounted for. From 8 to 10 per cent. of the remainder is discharged as unconsumed fuel from the stack during the operation of the locomotive and the remainder is required for the generation of steam.—*Dr. W. F. M. Goss before the Amer. Soc. Mech. Engrs.*

MOTOR FOR DRIVING TRANSFER TABLES AND BENDING ROLLS.

The "mill type" direct current motor which has recently been placed on the market by the Westinghouse Company is adapted to certain classes of railroad work, such as operating transfer tables and driving bending rolls in the boiler shop. It has been carefully designed to meet the severe conditions in steel mills, and has given very satisfactory results in that service.

When used on a transfer table it may be provided with two friction clutches, one operating the drum for pulling cars or dead engines on or off the table, the other operating the driving mechanism of the table. As it is possible to disconnect both clutches at the same time, there may be times when there is no load on the motor, and an ordinary series motor would run at a speed sufficient to cause damage to itself. This motor, however, has a shunt field connection, which limits the no load speed to approximately double the full load speed.

The illustration shows the motor opened for removal of the armature. The motor frame is divided horizontally and is hinged, allowing the upper half to be quickly swung back for repairs.



"MILL TYPE" DIRECT CURRENT MOTOR.

The heavy section of the frame insures freedom from vibration. The frame is provided with handholes for inspection of the commutator and windings, but the covers fit tightly and the frame is dustproof. The bearing housing is extended beyond the bearing and a dustproof construction is secured by means of a steel washer and felt lining.

The dimensions of the shaft are exceptionally large, with keyways of liberal dimensions, and all chance of bending and breaking is eliminated. A noticeable feature of the bearings is their large wearing surface, insuring long life. The air gap between the fields and the armature is large, and allows considerable wear in the bearings before the revolving and stationary parts can come in contact. Special provision has been made for preventing oil from being drawn into the armature or creeping along the shaft. The bearings are split and made interchangeable for either end of the motor. No dowel pins are used, as lugs cast on the bearings keep them from turning. An eye bolt on each bearing permits ready handling of the armature.

The insulation used on the motors is incombustible throughout, and withstands very high operating temperature without deterioration. The coils are treated with the insulating compound and then baked at a temperature far higher than any that will ever be met in actual service. The carbon holder is of substantial design, and so constructed that by the removal of one holding bolt the entire holder, as one piece, can be removed from the motor. The insulation is thoroughly protected from moisture and mechanical injury.

The armatures are wound with strap copper insulated with mica tape, handwound. This form of coil can be easily repaired, which is not possible with wire wound coils, which are useless if the insulation becomes badly damaged. The coils are held in place by hard fibre wedges and bands which are below the surface of the laminations.

A CORRECTION.—Through an error the Bridgeford 42-inch geared head engine lathe, described on page 191 of the May issue, was mentioned as a Bridgeport lathe. These machines are made by the Bridgeford Machine Tool Works, Rochester, N. Y.

PERSONALS.

N. L. Smitham, master mechanic of the Texas Midland R. R., has resigned.

A. C. Miller has been appointed to succeed N. L. Smitham as master mechanic of the Texas Midland R. R.

C. A Deweese, master mechanic of the Denver & Rio Grande Ry. at Helper, Utah, has resigned.

H. C. Eich, master mechanic of the Illinois Central R. R. at East St. Louis, has been transferred to Paducah, Ky., succeeding J. H. Nash.

J. H. Nash, master mechanic of the Illinois Central R. R., has been transferred from Paducah, Ky., to Waterloo, Ia., succeeding R. W. Bell, promoted.

A. Williamson, mechanical inspector, and F. J. Lass, mechanical engineer, of the Mexican Central Ry. at Aguascalientes, Mex., have exchanged positions.

W. C. Whittaker, formerly of Burnham, near Denver, Colo., has been transferred to Helper, Utah, as master mechanic, succeeding C. A. Deweese, resigned.

J. G. Neuffer, assistant superintendent of machinery of the Illinois Central R. R., has been appointed superintendent of machinery, succeeding Mr. Renshaw, resigned.

R. W. Bell, master mechanic of the Illinois Central R. R. at Waterloo, Iowa, has been appointed assistant superintendent of machinery, with office at Chicago, succeeding J. G. Neuffer, promoted.

A. S. Barrows, chief motive power clerk of the Chicago, Rock Island & Pacific Ry., has resigned to accept a similar position with the Delaware, Lackawanna & Western R. R., with office at Scranton, Pa.

W. Cockfield, locomotive superintendent of the Mexican Railway, at Orizaba, Ver., has resigned to accept the position of chief locomotive superintendent of the Peruvian Corporation, with headquarters at Lima, Peru.

H. O. Keay has been elected head of the department of railways at McGill University, Montreal, to succeed Clarence Morgan, who has resigned to re-enter active railroad work. The railway department, which was organized a year or two ago, has become firmly established and organized.

Orlando Stewart, formerly superintendent of motive power of the Bangor & Aroostook Ry., died at his home in Brighton, Mass., on the 27th of April, aged 74 years. Mr. Stewart retired from railroad work last fall and has been in failing health for some time. He is mourned by a wide circle of friends and his death removes a veteran railroader from the ranks.

J. R. Thompson has been appointed mechanical engineer of the Chicago Great Western Ry., with headquarters at Oelwein, Ia. Mr Thompson was formerly mechanical engineer of the Fitz Hugh, Luther Co. at Hammond, Ind.

William Renshaw, superintendent of machinery of the Illinois Central R. R., has resigned from the service of the company. Mr. Renshaw entered the service of the Illinois Central in the drafting department in 1865. From 1869 to 1882 he filled the positions of machinist apprentice, journeyman machinist, engine house foreman and general foreman. In 1882 he was appointed master mechanic of the Chicago division and later assistant superintendent of machinery, which latter position he occupied until 1893, when he was appointed superintendent of machinery.

Walter Gilman Berg, chief engineer of the Lehigh Valley R. R., president of the American Railway Engineering and Maintenance of Way Association and past president of the Association of Railway Superintendents of Bridges and Buildings, died very suddenly on May 12 from an acute attack of indigestion. Mr. Berg has been known as one of the foremost railroad engineers in the country and was a man of fine education and large experience. He was the author of a number of valuable books, among which the best known is "Buildings and Structures of American Railways," a standard work on this subject. He was also the author of "Railway Shop Systems."

CATALOGS

IN WRITING FOR THESE PLEASE MENTION THIS JOURNAL.

Souvenir Book of Cars.—The Barney & Smith Car Company, Dayton, O., is issuing a limited edition of a very attractive souvenir book entitled "Cars We Have Built." The book is given up entirely to full page illustrations of the exterior and interior of all classes of passenger cars, including sleeping, buffet and dining cars. Views of both box and gondola cars, the latter of composite or all steel construction, are also included. The book forms an excellent collection of views showing the very attractive and artistic interior of modern passenger equipment.

Electrical Apparatus.—Among the recent bulletins issued by the General Electric Company might be mentioned No. 4582, which describes the G. E. 205 railway motor. This motor is similar in design and construction to other standard G. E. motors but is provided with commutating poles located between the main field poles. This type of motor is especially adapted for use with high operating voltage and hence, for operation on heavy grades, or with equipments intended for high speed work, which have to start and stop frequently, it is unusually well fitted. Bulletin No. 4585 is on the subject of the QC motor, which is made in sizes up to 20 h. p. and for voltages of 115, 230 and 550 direct current. This motor is especially adapted for application to machine tools.

Vertical Self-Oiling Engines.—The American Blower Company, Detroit, Michigan, is issuing catalog No. 232, superseding No. 206. which is given up entirely to the illustrating and describing of vertical self-oiling steam engines. These engines are of the small high speed type and they often run for five months on a stretch without any other attention than filling the cylinder lubricator and after that time they simply need a renewal of the interior supply of oil. They are most completely illustrated and described in the catalog, every small detail being carefully considered. They are made in practically all sizes, either with a single or double cylinder, up to 65 h. p. and will operate in some sizes as high as 800 r. p. m. The catalog includes tables showing the remarkable economy which has been attained and gives details of prices, weights and sizes.

NOTES

Kennicott Water Softener Co.—W. R. Toppan has resigned the position of general manager of this company.

Gould Coupler Company.—Mr. F. P. Huntley, vice-president and general manager of the above company, has just returned from a trip of some few months abroad, where he has been on business and pleasure.

S. F. Bowser & Company.—Among the guests who lost their lives in the recent burning of the Aveline Hotel in Fort Wayne, Ind., was Mr. William A. Pitcher, who held the position of eastern railway representative of S. F. Bowser & Company. Mr. Pitcher was forty-eight years of age.

Goldschmidt Thermit Co.—This company announces the establishment of an office and works at 103 Richmond Street West, Toronto, Canada. This office is under the management of Mr. E. C. Rutherford, a Canadian by birth and a man of wide acquaintance in the Dominion.

Turbine Activities in the Far East.—Included in a recent shipment from the Westinghouse plant at East Pittsburg there were not less than ten turbo-electric generators, aggregating 25,000 h. p., which are for service in the Far East, most of the machines going to Japan.

Cassier's Magazine Moves.—The Cassier Magazine Company announces the removal of its New York offices from 3 W. 29th streeet to 12 W. 31st street. The new address is located in an office building which has just been erected on the site of the former house of the American Society of Mechanical Engineers.

Crocker Wheeler Company.—Herbert C. Petty was on May 13th elected a director of the Crocker Wheeler Company of Ampere, N. J. Mr. Petty entered the service of this company in 1903, in the sales division, from which he was advanced to the position of contract manager, which position he held up to the present time.

Walter B. Snow.—Mr. Snow, who opened an office as publicity engineer some time ago, has recently increased his facilities by removal to larger quarters at 170 Summer street, Boston, Mass. He has also established an addressing and mailing department in connection with which select mailing lists will be maintained for the special use of his clients.

Mechanical Stokers.—One of the largest orders ever placed for mechanical stoking equipment was received by the Westinghouse Machine Company just at the close of the year 1907. This order aggregated 14,400 boiler h. p. and was made up of 24 stokers to be used in one of the large Brooklyn power stations operated by the Transit Development Company of New York.

Fairbanks, Morse & Co.—The general offices and sales department of this company, formerly at the corner of Franklin and Monroe streets, moved during the month of April, and are now located in their new building with offices at the corner of Wabash avenue and Eldredge place, Chicago. This is the home office of the company. The new office building is a seven-story structure, with basement.

Locomotives Ordered.—Among the recent orders received by the American Locomotive Company was a six-wheel switching engine for the Saint Louis National Stock Yards; a consolidation locomotive for the Fajardo Sugar Company and two Mallet type locomotives for the Eastern Railway of France. Orders were also received from the Paris-Orleans Railway for one 10 ft. 7 in. cut, scoop wheel type, standard gauge, rotary snow plow.

American Blower Co.—The above company announces that it has purchased the foundry formerly operated by the Northwestern Foundry & Supply Company of Detroit, Mich. This foundry will be used for the manufacture of blower, exhaust fan, engine and heater castings. It announces that all of the soil pipe and fittings patterns, the complete foundry equipment and also a large stock of finished pipe fittings, etc., which were purchased with the foundry, are for sale.

Consulting Engineer.—Mr. J. Fremont Murphy, who for a number of years has been connected with the Cooke Works of the American Locomotive Company as engineer and superintendent, has opened an office in New York as a consulting engineer. He will make a specialty of railroad equipment and is available for consultations, investigations, appraisements, expert testimony, inspection, perfection of inventions and the making of tests. His office address is 1824 Hudson Terminal-Cortlandt Building.

Canadian Crocker Wheeler Co., Ltd.—A new company, having the above name, has recently been organized for the manufacture and sale in Canada of the well known Crocker Wheeler apparatus. Mr. F. E. Lovell, a member of a very long established lumbering firm in the province of Quebec, has been elected president of the company. Messrs. Russell A. Stinson and F. Jno. Bell, vice-president and secretary-treasurer respectively, have also long been identified with the manufacturing, construction and sale of the electrical apparatus in Canada. The head office of the new company has been opened in the Street Railway Chambers, Place d'Armes Hill, Montreal.

The American Nut and Bolt Fastener Company.—This company has moved into its new plant at Ontario and Sterling streets, North Side, Pittsburgh, Pa. The company owns an entire city block and the buildings have been placed to the best possible advantage. The plant is convenient to a railroad and has connecting switches. The main building is 80 by 215 ft. and is equipped with new and the most improved machinery for manufacturing the Bartley fasteners. All of the machinery is driven by electric power. The latest improvements in the way of toilet and wash rooms are provided for the comfort of the employees. The plant has a capacity for 60,000,000 Bartley fasteners per annum; these fasteners are made in over seven hundred different styles. Bartley fasteners are sold to nearly all the railroads and car companies in the United States and to a large foreign trade. Fourteen million of these fasteners were sold during the year 1907. The company is represented in the East by Robert Spencer & Co., 20 Vesey street, New York, and in the west by Christopher Murphy & Co., 164 Dearborn street, Chicago. The main office address of the company is Post Office Box 996, Pittsburgh, Pa.

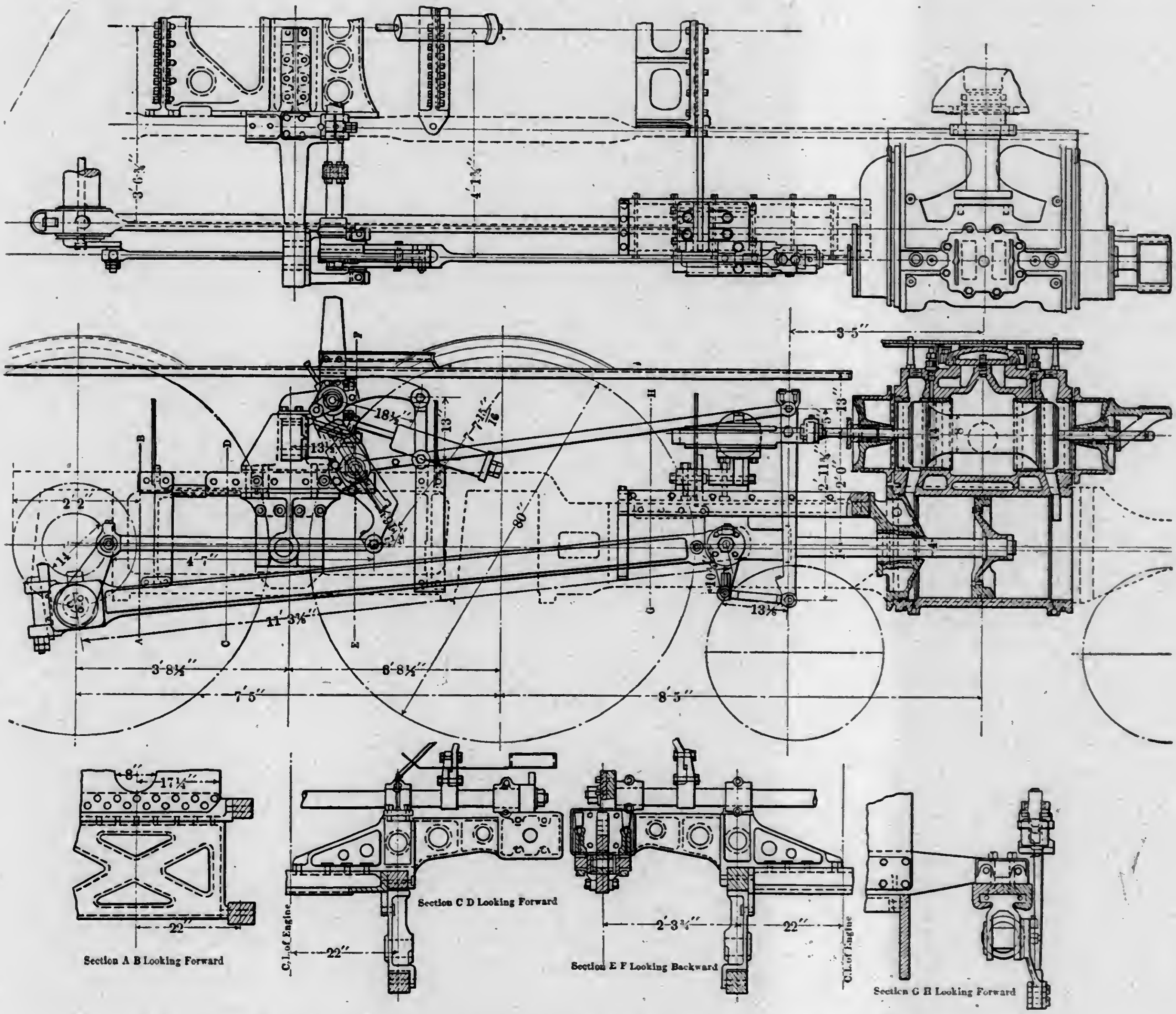
WALSCHAERT VALVE GEAR.*

PENNSYLVANIA RAILROAD.

The design of valve gear which has been developed on the Pennsylvania Railroad for use on high speed Atlantic type locomotives presents many features of refinement of detail and attention to the underlying principles of a gear of the Walschaert type which are not always found in the gears being applied. It consists of as few parts as can be used to advantage and still obtain a satisfactory motion. All moving parts are made as light as stiffness would allow and particular attention has been given to providing case hardened bushings and pins at all wearing points. Full advantage has also been taken of the opportunity presented by the use of this type of gear in obtaining an exceptionally good system of frame bracing.

The general assembled drawing of the gear shows the supports for the different parts very clearly, and a study of that drawing will show that the great importance of an absolutely rigid support for the link has been fully appreciated. Since this section of the gear must be located back of the front driver and with the center of its trunnions some distance ahead of the point midway between the drivers, it is necessary to support it from a cantilever extending out a distance of over 2 ft. from the main frames. As the link is hung 13½ in. ahead of this extending arm, a twisting action is introduced which must be opposed by a liberal length of bearing on the frame.

The construction at this point consists of a steel casting which is cored at all available points to make it as light as possible and still retain the requisite stiffness. This casting extends inward to the center line of the engine, being securely bolted to a large horizontal frame stiffening casting located at this point. It has a bearing nearly 2 ft. long on the frame with a deep lip extending down on the outside and is secured to the frame by four vertical and four horizontal bolts. At the outer end is carried a steel casting which includes the bearing for the link trunnions. A bearing for the end of the reverse shaft is also provided in this casting, the construction and arrangement of which is clearly

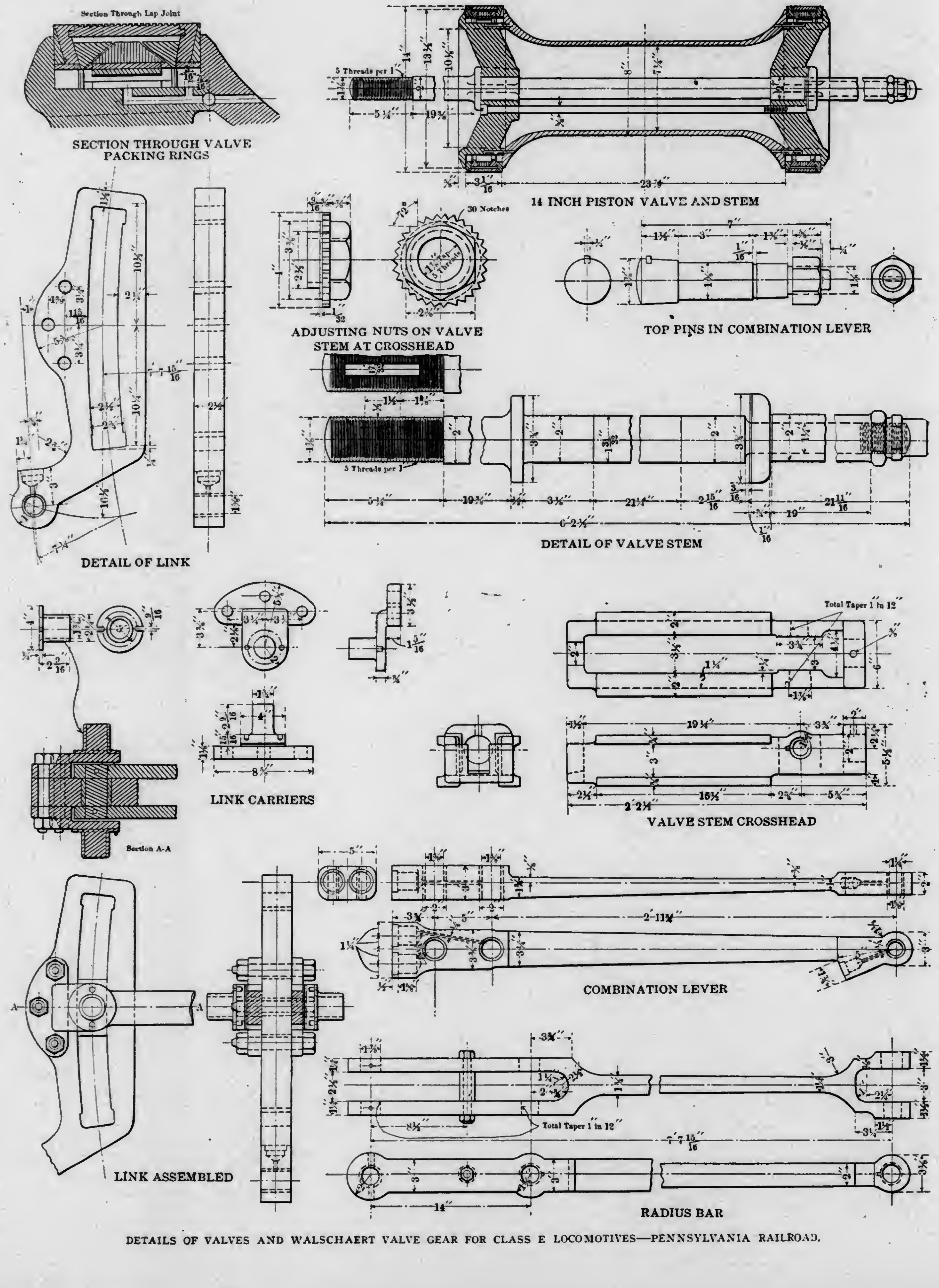


PLAN AND ELEVATIONS OF ASSEMBLED VALVE GEAR OF THE WALSCHAERT TYPE—PENNSYLVANIA RAILROAD.

* This is the fourth article of a series describing in detail typical arrangements of the Walschaert valve gear. The standard arrangement used on consolidation locomotives on the Canadian Pacific Railway was described on page 16 of the January, 1908, issue. A typical application made by the American Locomotive Company to some Pacific type locomotives for the Florida East Coast Railway was described on page 89 of the March, 1908, issue. Details of the Walschaert gear used on a recent order of Pacific type locomotives furnished to the A. T. & S. F. Ry. by the Baldwin Locomotive Works were described on page 114 of the March, 1908, issue.

shown in the assembled drawing. The reverse shaft, which extends across the engine, is provided with another bearing just above the frame, this being in a separate casting bolted to the top of the cantilever.

The frame stiffening pieces at this point, which consist of vertical steel castings located just ahead of the rear pedestal and behind the front pedestal, and two large horizontal steel castings, being designed to give great stiffness without excessive



DETAILS OF VALVES AND WALSCHAERT VALVE GEAR FOR CLASS E LOCOMOTIVES—PENNSYLVANIA RAILROAD.

VIEW OF WALSCHAERT VALVE GEAR AS APPLIED TO CLASS E3D LOCOMOTIVE—PENNSYLVANIA RAILROAD.

weight, are worthy of attention. Another horizontal frame stiffening casting will also be noticed just back of the guide yoke, where the frame narrows down to a 2½ in. plate.

The support of the forward part of the gear is provided by the valve stem cross head which has very liberal bearing area and is carried in guides, supported from the top of the main guide just ahead of the yoke. It will be noticed that an extension valve stem with a stuffing box and bearing in the front valve chamber head is used, which will assist in keeping this section of. the gear in line and relieve the cross head to some extent.

The illustrations of the details of the gear show its refinement and extreme lightness combined with sufficient rigidity to prevent it from springing or otherwise getting out of adjustment at very high speeds. The whole gear, from the center of the pin on the return crank to the center of the valve stem, is all in one vertical plane, so that no horizontal lever arms are introduced at any point. Provision has been made throughout for the convenient and easy removal of any part which may need attention, without dismantling other sections. The return crank is held to the main pin by a bolt extending through the center of the pin and is held to its setting by three stud bolts. The method of carrying the link is also very simple and effective. Complete provision has been made for lubrication by means of oil cups incorporated in different members.

The connection between the valve stem and the cross head is capable of adjustment for setting the valve central after the gear has been erected. This is a provision which is not usually found in the Walschaert valve gear in this country and was adapted from the design applied to the De Glehn compound owned by the Pennsylvania. The arrangement consists of extending the valve stem through an opening in the cross head and securing it by a large nut on either side. These nuts are provided with a flange having 30 teeth cut in its circumference. A locking device is provided which securely fastens both nuts. This arrangement has not proven to be entirely satisfactory and the latest gears have the stem keyed to the cross head and an adjustment provided at the valve itself.

One of the illustrations shows the type of piston valve used on these locomotives, with an enlarged section through the packing ring. These valves were furnished by the American Balanced Valve Co.

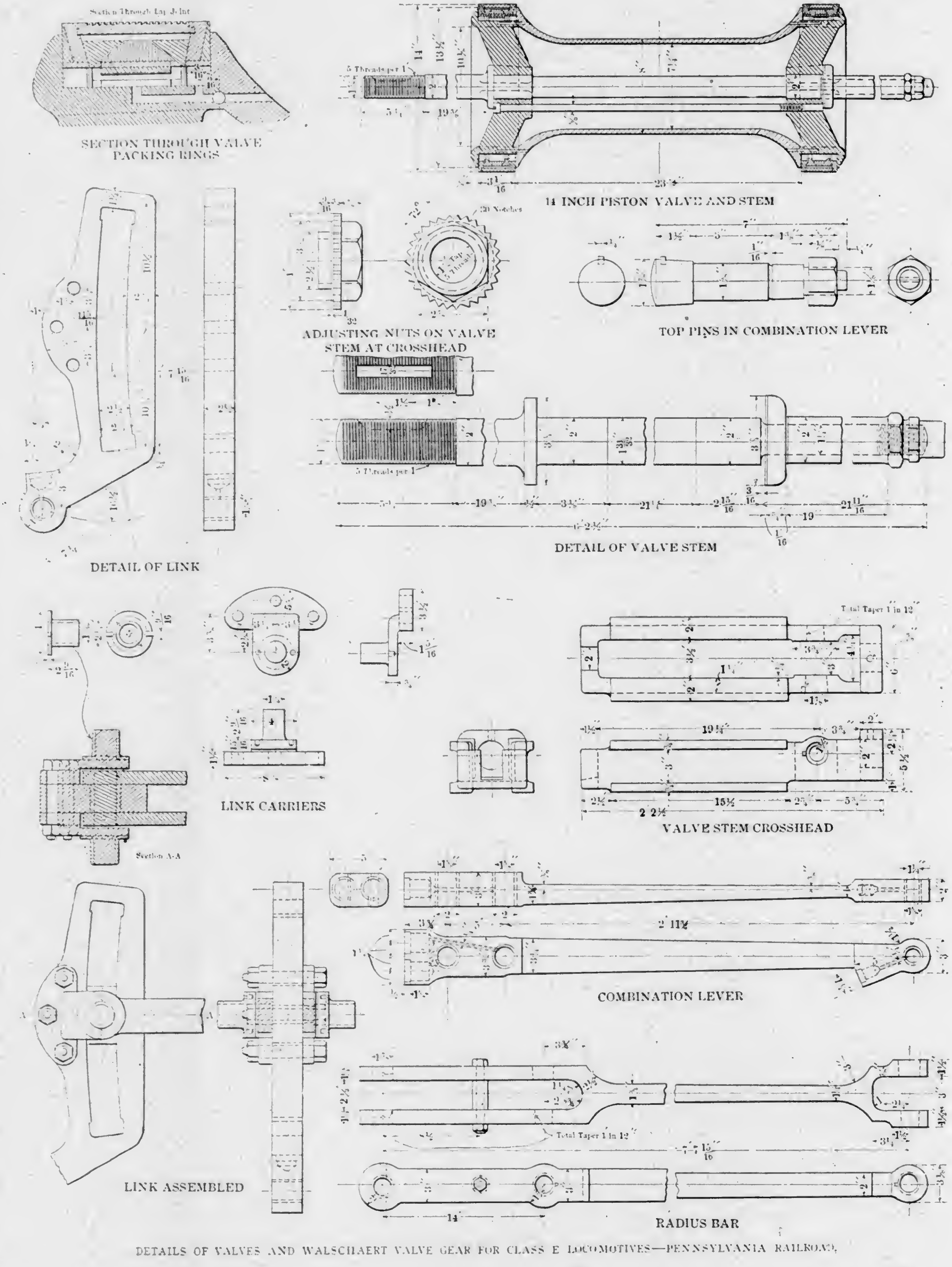
A LABOR LEADER'S INDORSEMENT OF A RATIONAL RAILROAD APPRENTICESHIP SYSTEM.—Summing up the whole question of industrial education, as it is supposed to apply to the young men, I am firmly convinced that every precaution should be taken concerning such schools (trade schools), to the end that young men will not be induced or led to believe that after serving a few months, or a year if you will, in an industrial or trades school, by securing certificates they are permitted or even warranted in going into the industrial field seeking employment as mechanics, against the best interests of those who have served a reasonable or legal apprenticeship. To avoid this danger, and with a view to securing the highest skill and to perpetuate the supremacy of the American mechanic, I believe that the proper and best methods to be adopted are for employers to establish schools in connection with their factories and workshops, for the purpose of giving young men employed by them an opportunity for a few hours' schooling each day, in addition to the practical experience they are securing while serving their time as apprentices. To my mind this idea is best carried out by the New York Central Lines, as represented by Mr. Deems.—*From an Address by James O'Connell, President of the International Association of Machinists, before the Civic Federation of New England.*

IMPROVING THE EFFICIENCY OF THE CAR WHEEL.—Finally, to summarize the points that I have endeavored to make and laying aside, for the present, the matter of improving the quality of the wheel, which is a work that must necessarily go on, I would suggest first, avoid the concentration of load by the use of a more satisfactory relation between the contour of the wheel and that of the rail; second, avoid the concentration of heat at or near the flange of the wheel by a modification of the brake practice; third, relieve the oftentimes existing high pressures against the flange by introducing the feature of lateral motion in truck construction, so that a considerable yielding resistance will be offered instead of an abrupt one; fourth, for the purpose of avoiding the excessive wear of wheel flanges of all kinds, modify the contour and provide means whereby the resistance to the pivoting of the truck and of the wheels to track may be very materially reduced.—*S. P. Bush before the Western Railway Club.*

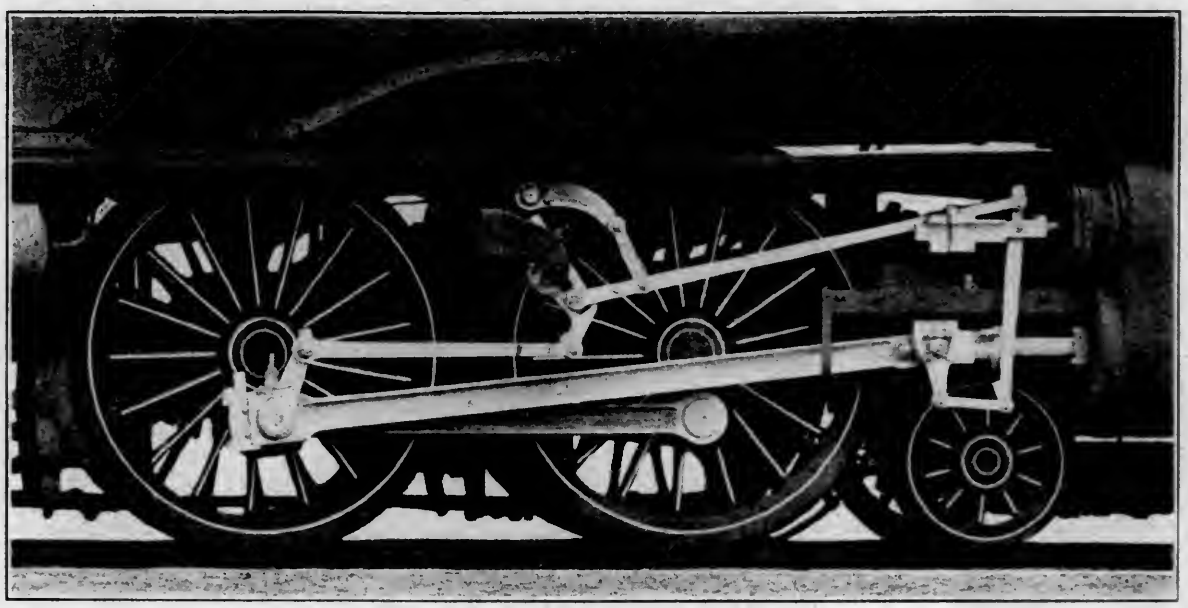
THE FASTEST LONG DISTANCE RUN.—The Pennsylvania has achieved the distinction of carrying a theatrical company from Pittsburg to Chicago in 7 hours and 42 minutes. The special train used was made up of two 60-foot baggage cars and two sleepers. The distance covered was 468 miles, so that the average speed was a fraction under 61 miles an hour, including stops. It is claimed that never before has such a high average speed been maintained for so great a distance by a passenger train. The special was stopped four times and slowed down once by the block signals to prevent overrunning the Pennsylvania's 18-hour train. One of the forced stops was five minutes and the others were nearly as long.

shown in the assembled drawing. The reverse shaft, which extends across the engine, is provided with another bearing just above the frame, this being in a separate casting bolted to the top of the cantilever.

The frame stiffening pieces at this point, which consist of vertical steel castings located just ahead of the rear pedestal and behind the front pedestal, and two large horizontal steel castings, being designed to give great stiffness without excessive



DETAILS OF VALVES AND WALSCHAERT VALVE GEAR FOR CLASS E LOCOMOTIVES—PENNSYLVANIA RAILROAD.



VIEW OF WALSCHAERT VALVE GEAR AS APPLIED TO CLASS E3D LOCOMOTIVE—PENNSYLVANIA RAILROAD.

weight, are worthy of attention. Another horizontal frame stiffening casting will also be noticed just back of the guide yoke, where the frame narrows down to a 2½ in. plate.

The support of the forward part of the gear is provided by the valve stem cross head which has very liberal bearing area and is carried in guides supported from the top of the main guide just ahead of the yoke. It will be noticed that an extension valve stem with a stuffing box and bearing in the front valve chamber head is used, which will assist in keeping this section of the gear in line and relieve the cross head to some extent.

The illustrations of the details of the gear show its refinement and extreme lightness combined with sufficient rigidity to prevent it from springing or otherwise getting out of adjustment at very high speeds. The whole gear, from the center of the pin on the return crank to the center of the valve stem, is all in one vertical plane, so that no horizontal lever arms are introduced at any point. Provision has been made throughout for the convenient and easy removal of any part which may need attention, without dismantling other sections. The return crank is held to the main pin by a bolt extending through the center of the pin and is held to its setting by three stud bolts. The method of carrying the link is also very simple and effective. Complete provision has been made for lubrication by means of oil cups incorporated in different members.

The connection between the valve stem and the cross head is capable of adjustment for setting the valve central after the gear has been erected. This is a provision which is not usually found in the Walschaert valve gear in this country and was adapted from the design applied to the De Glehn compound owned by the Pennsylvania. The arrangement consists of extending the valve stem through an opening in the cross head and securing it by a large nut on either side. These nuts are provided with a flange having 30 teeth cut in its circumference. A locking device is provided which securely fastens both nuts. This arrangement has not proven to be entirely satisfactory and the latest gears have the stem keyed to the cross head and an adjustment provided at the valve itself.

One of the illustrations shows the type of piston valve used on these locomotives, with an enlarged section through the packing ring. These valves were furnished by the American Balanced Valve Co.

A LABOR LEADER'S INDORSEMENT OF A RATIONAL RAILROAD APPRENTICESHIP SYSTEM.—Summing up the whole question of industrial education, as it is supposed to apply to the young men, I am firmly convinced that every precaution should be taken concerning such schools (trade schools), to the end that young men will not be induced or led to believe that after serving a few months, or a year if you will, in an industrial or trades school, by securing certificates they are permitted or even warranted in going into the industrial field seeking employment as mechanics, against the best interests of those who have served a reasonable or legal apprenticeship. To avoid this danger, and with a view to securing the highest skill and to perpetuate the supremacy of the American mechanic, I believe that the proper and best methods to be adopted are for employers to establish schools in connection with their factories and workshops, for the purpose of giving young men employed by them an opportunity for a few hours' schooling each day, in addition to the practical experience they are securing while serving their time as apprentices. To my mind this idea is best carried out by the New York Central Lines, as represented by Mr. Deems.—*From an Address by James O'Connell, President of the International Association of Machinists, before the Civic Federation of New England.*

IMPROVING THE EFFICIENCY OF THE CAR WHEEL.—Finally, to summarize the points that I have endeavored to make and laying aside, for the present, the matter of improving the quality of the wheel, which is a work that must necessarily go on, I would suggest first, avoid the concentration of load by the use of a more satisfactory relation between the contour of the wheel and that of the rail; second, avoid the concentration of heat at or near the flange of the wheel by a modification of the brake practice; third, relieve the oftentimes existing high pressures against the flange by introducing the feature of lateral motion in truck construction, so that a considerable yielding resistance will be offered instead of an abrupt one; fourth, for the purpose of avoiding the excessive wear of wheel flanges of all kinds, modify the contour and provide means whereby the resistance to the pivoting of the truck and of the wheels to track may be very materially reduced.—*S. P. Bush before the Western Railway Club.*

THE FASTEST LONG DISTANCE RUN.—The Pennsylvania has achieved the distinction of carrying a theatrical company from Pittsburg to Chicago in 7 hours and 42 minutes. The special train used was made up of two 60-foot baggage cars and two sleepers. The distance covered was 468 miles, so that the average speed was a fraction under 61 miles an hour, including stops. It is claimed that never before has such a high average speed been maintained for so great a distance by a passenger train. The special was stopped four times and slowed down once by the block signals to prevent overrunning the Pennsylvania's 18-hour train. One of the forced stops was five minutes and the others were nearly as long.

INTERIOR OF STRANG GAS-ELECTRIC CAR "IRENE."

GAS-ELECTRIC RAILWAY MOTOR CAR.

Early in 1906 the Strang Gas-Electric Car Company, New York built the first motor car using its system of power generation and transmission, which was put into service on the Missouri & Kansas Interurban Railway. This car was illustrated and described on page 103 of the March, 1906, issue of this journal. It was followed by several other cars employing the same system, each one being an enlargement and improvement over its predecessor. This series of cars has now received the addition of a very powerful motor car of all-steel construction, which has recently been turned out by the J. G. Brill Company, Philadelphia. This car is named the "Irene," and is shown in the accompanying illustrations.

The Strang system for motor cars consists of a four-cycle six-cylinder gas engine direct connected to a direct current generator supplying current to electric motors on the trucks. In addition there is carried underneath the car floor a large storage battery, which is charged during stops, in coasting down grades, or at other times when the supply of the current from the generator is greater than is required by the motors. This arrangement of storage batteries permits the installation of an electric generator, which is of a size sufficient to meet the normal requirements of operation only. Any excessive call for current can be supplied by calling on the battery to assist the generator. The current from the battery is also used for starting the gas engine by converting the generator into a motor until the engine picks up its charge and is in operation. The electrical connections in this system are such that the battery automatically comes to the assistance of the generator when needed or is automatically charged by absorbing the surplus when the generator supplies more current than is needed by the motors.

The car illustrated is 66 ft. over all and has a capacity of 75 seated passengers. The 150 h.p. gas engine is of the vertical type direct connected to an 85 k.w. shunt wound interpole generator. The motors, of which there are two, are of 100 h.p. capacity each and are of the series wound interpole type. The storage battery contains 112 cells and has a 150 ampere hour capacity.

The car body is of steel construction throughout, with the exception of the interior finish, which is of vermillion wood. The power plant is located at the head end of the car and separated from the other compartments by a partition. Directly behind it is a compartment arranged with transverse seats upholstered in red leather. This section is separated from the rear compartment, which is fitted with wicker chairs and other conveniences of a club car, by a grill partition. An observation platform, surrounded by brass rails, is provided at the rear end

STRANG GAS-ELECTRIC CAR "IRENE."

of the car. The interior finish and arrangement is very elaborate, the lighting, of course, being by electricity. It is heated by the hot water from the engine jackets which is circulated by means of a motor driven centrifugal pump. During the summer seasons the jacket water is passed through a radiator on the roof of the car.

The car weighs, in working order, 57 tons and is capable of hauling three light trailer cars seating 75 passengers each. It is equipped with multiple unit control and can thus be used as a source of power for a number of motor cars connected to it.

This car was on exhibition at the mechanical conventions at Atlantic City, where it was the center of much interest and brought forth many favorable comments.

FREIGHT CAR INTERCHANGE.

The present rules governing freight car interchange were formulated and have been in effect under a period of almost continuous increase in traffic, which has taxed to the utmost the ability of the railroads to provide facilities for its proper handling. These rules are founded on the principle that every car owner has a right to the control of his cars, and each successive change in rules or rates simply emphasized this right.

This principle, although based on strict equity, has had opposed to it the inevitable tendency toward a free interchange or common use of those classes of cars which are adapted to the handling of the general traffic exchanged between railroads.

The extent to which this natural tendency has prevailed over artificial regulations at variance with it, is denoted by the figures showing the per cent. of foreign cars in use on all lines, which increased from 30 per cent. in 1904, to 41 per cent. for the first six months of 1907.

There is food for thought in the fact that the rate of rental for car hire which has not availed in times of car shortage to secure the car owner in the use of his property, operated so effectively immediately on the appearance of a car surplus as to create a new difficulty, the excessive and useless cross haul of empty cars.

It will be noted that the per cent. of cars on their home roads, which was but 56 per cent. during the first half of 1907, and only 54 per cent. during the month of April, 1907, averaged 64 per cent. in December, with indications that the homeward movement had only fairly started. Had this change been accomplished in the natural course of traffic, it might be accepted as a silver lining to the cloud of general depression, but unfortunately it was brought about only at great expense.

The proportion of empty to total freight car mileage in December was 35.4 per cent. as against 27.1 per cent. in October, an increase of 8.3 per cent. It is fair to assume that the average business can be handled with at least as low a percentage of empty mileage when the car supply is plentiful as during a period of shortage, and it would therefore appear that 8.3 per cent. of the total car mileage, or 117,287,407 miles, was absolutely unnecessary. It is impossible to calculate the cost of this enormous empty movement, but that it was a heavy drain on the already depleted revenues of the railroads, cannot be denied. It may be claimed that the saving made by individual roads in per diem balances justified the expenditure which this excess empty movement entailed, but the fallacy of this claim is apparent in the face of the fact that the gain by one line was necessarily offset by the loss to another. Further, in a majority of cases, the movement resulted in practically an even exchange of cars.

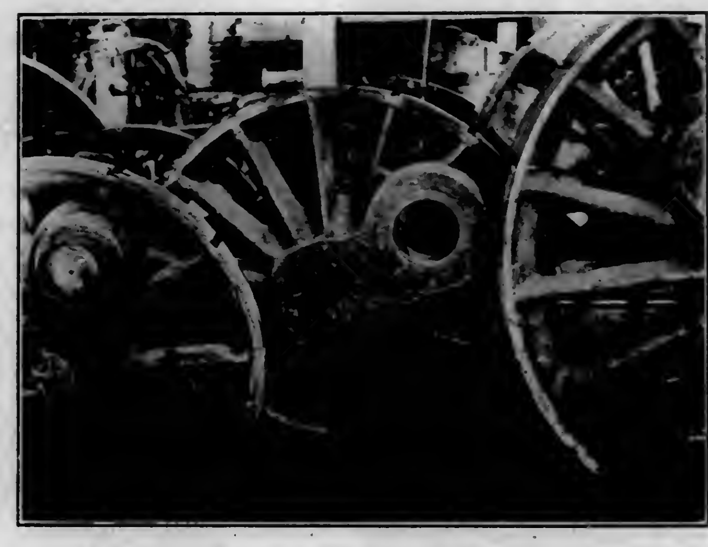
Nor was this wasteful empty movement the only deplorable result of the unfortunate position in which the railroads found themselves. In the efforts to keep per diem balances on the proper side, a great many roads took extreme measures to reduce the number of foreign cars on their lines and to force their own cars into service. Roads which had during the period of shortage, gladly accepted cars belonging to affiliated lines, revised their rules when cars became plentiful and refused to accept cars not properly routing over their lines. Foreign cars were in many instances stopped at junction points and their lading transferred to home cars. In other cases home cars were applied on loading to foreign lines, while foreign cars were sent home empty in the same direction.

There is one encouraging sign in the situation created by the extraordinary developments of the past few months. It is that the experience gained at such great cost may lead to the adoption of more flexible rules governing the use of freight cars in interline traffic. To the extent that such rules recognize the necessity for free interchange of cars, with such regulation as the principle of private ownership demands, to that extent will the future efficiency of freight cars be increased.—*Arthur Hale, Chairman, Committee on Car Efficiency, The American Railway Association.*

TURNING DRIVING WHEEL TIRES.

It is often necessary to change and re-turn the tires of an engine two or three times between shoppings. When the tires are sent to the shop for re-turning, the usual practice is to shrink them on an old pair of wheel centers, mounted on an axle, and turn them in the driving wheel lathe. The cost of the labor and gasoline for shrinking the tires on and removing them is considerable. One shop has found that it could handle the tires at about one-half of the cost of turning them in this way by turning them, one at a time, on a boring mill. The mill was an old one and not equipped with a universal chuck.

At the St. Paul shops of the Great Northern Railway a still



MANDRELS FOR TURNING TIRES.

different method is followed. Old driving wheel centers for 48, 56 and 66 in. wheels are mounted on scrap axles and turned so that the tires will slip over them neatly. Taper key-ways are slotted in the circumference about 18 in. apart. When the tire is slipped on the center, taper keys (1/16 in. to 1 ft.) are driven in, thus holding the tires securely in the centers. The slot and the keys are tapered so that the face of the key and the inside of the tire are parallel when the key is driven tight. They are then turned in the wheel lathe. Only a few minutes are required to set the tires on the centers and the arrangement is said to be very satisfactory. Three sets of these mandrels are all that are required to take care of the greater proportion of the driving wheels in use on the Great Northern; the mandrels when not in use are stored alongside the lathe. A partial view of these mandrels is shown in the accompanying illustration.

RELATIVE USE OF STEAM, WATER POWER, ETC.—Of the total estimated power at present produced by prime movers in this country, about 26,000,000 horse-power is produced by steam engines, 3,000,000 horse-power by water motors and 700,000 horse-power by gas and oil engines.—*H. St. Clair Putnam before the Conference on the Conservation of Natural Resources.*

INTERIOR OF STRANG GAS-ELECTRIC CAR "IRENE."

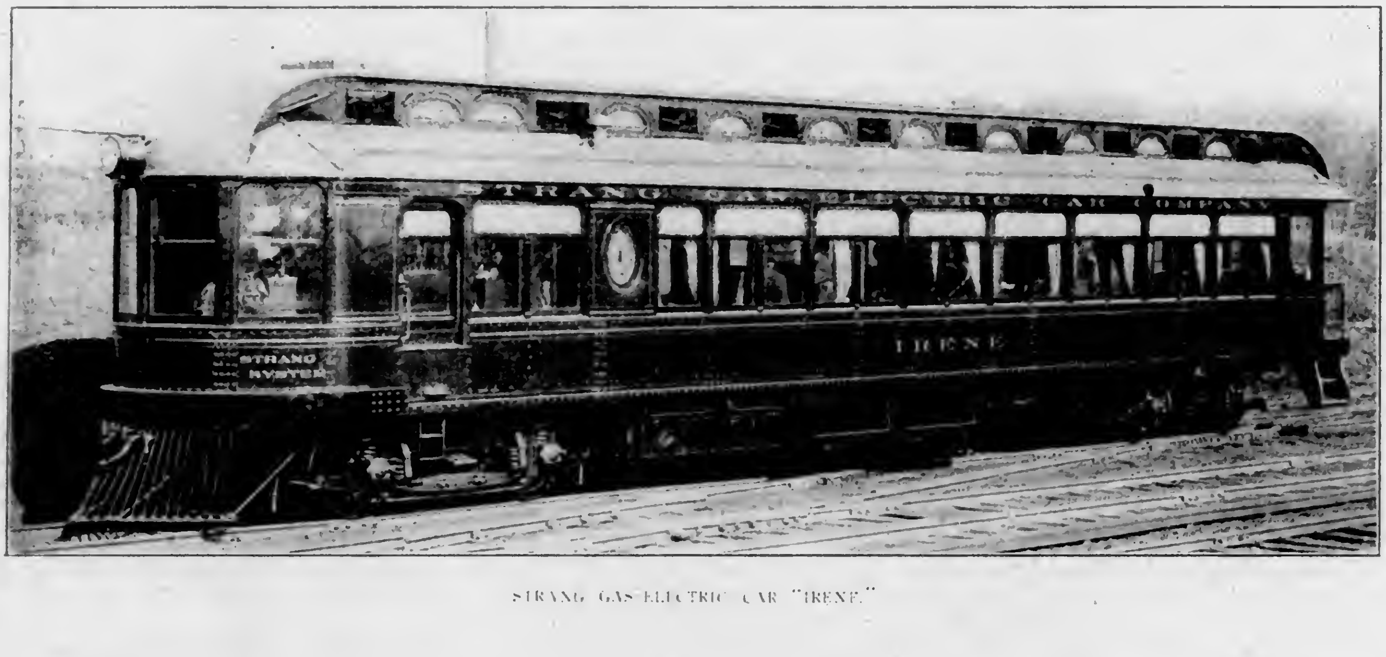
GAS-ELECTRIC RAILWAY MOTOR CAR.

Early in 1906 the Strang Gas-Electric Car Company, New York built the first motor car using its system of power generation and transmission, which was put into service on the Missouri & Kansas Interurban Railway. This car was illustrated and described on page 103 of the March, 1906, issue of this journal. It was followed by several other cars employing the same system, each one being an enlargement and improvement over its predecessor. This series of cars has now received the addition of a very powerful motor car of all-steel construction, which has recently been turned out by the J. G. Brill Company, Philadelphia. This car is named the "Irene," and is shown in the accompanying illustrations.

The Strang system for motor cars consists of a four-cycle six-cylinder gas engine direct connected to a direct current generator supplying current to electric motors on the trucks. In addition there is carried underneath the car floor a large storage battery, which is charged during stops, in coasting down grades, or at other times when the supply of the current from the generator is greater than is required by the motors. This arrangement of storage batteries permits the installation of an electric generator, which is of a size sufficient to meet the normal requirements of operation only. Any excessive call for current can be supplied by calling on the battery to assist the generator. The current from the battery is also used for starting the gas engine by converting the generator into a motor until the engine picks up its charge and is in operation. The electrical connections in this system are such that the battery automatically comes to the assistance of the generator when needed or is automatically charged by absorbing the surplus when the generator supplies more current than is needed by the motors.

The car illustrated is 66 ft. over all and has a capacity of 75 seated passengers. The 150 h.p. gas engine is of the vertical type direct connected to an 85 k.w. shunt wound interpole generator. The motors, of which there are two, are of 100 h.p. capacity each and are of the series wound interpole type. The storage battery contains 112 cells and has a 150 ampere hour capacity.

The car body is of steel construction throughout, with the exception of the interior finish, which is of vermillion wood. The power plant is located at the head end of the car and separated from the other compartments by a partition. Directly behind it is a compartment arranged with transverse seats upholstered in red leather. This section is separated from the rear compartment, which is fitted with wicker chairs and other conveniences of a club car, by a grill partition. An observation platform, surrounded by brass rails, is provided at the rear end



STRANG GAS-ELECTRIC CAR "IRENE."

of the car. The interior finish and arrangement is very elaborate, the lighting, of course, being by electricity. It is heated by the hot water from the engine jackets which is circulated by means of a motor driven centrifugal pump. During the summer seasons the jacket water is passed through a radiator on the roof of the car.

The car weighs, in working order, 57 tons and is capable of hauling three light trailer cars seating 75 passengers each. It is equipped with multiple unit control and can thus be used as a source of power for a number of motor cars connected to it.

This car was on exhibition at the mechanical conventions at Atlantic City, where it was the center of much interest and brought forth many favorable comments.

FREIGHT CAR INTERCHANGE.

The present rules governing freight car interchange were formulated and have been in effect under a period of almost continuous increase in traffic, which has taxed to the utmost the ability of the railroads to provide facilities for its proper handling. These rules are founded on the principle that every car owner has a right to the control of his cars, and each successive change in rules or rates simply emphasized this right.

This principle, although based on strict equity, has had opposed to it the inevitable tendency toward a free interchange or common use of those classes of cars which are adapted to the handling of the general traffic exchanged between railroads.

The extent to which this natural tendency has prevailed over artificial regulations at variance with it, is denoted by the figures showing the per cent. of foreign cars in use on all lines, which increased from 30 per cent. in 1904, to 41 per cent. for the first six months of 1907.

There is food for thought in the fact that the rate of rental for car hire which has not availed in times of car shortage to secure the car owner in the use of his property, operated so effectively immediately on the appearance of a car surplus as to create a new difficulty, the excessive and useless cross haul of empty cars.

It will be noted that the per cent. of cars on their home roads, which was but 56 per cent. during the first half of 1907, and only 54 per cent. during the month of April, 1907, averaged 64 per cent. in December, with indications that the homeward movement had only fairly started. Had this change been accomplished in the natural course of traffic, it might be accepted as a silver lining to the cloud of general depression, but unfortunately it was brought about only at great expense.

The proportion of empty to total freight car mileage in December was 35.4 per cent. as against 27.1 per cent. in October, an increase of 8.3 per cent. It is fair to assume that the average business can be handled with at least as low a percentage of empty mileage when the car supply is plentiful as during a period of shortage, and it would therefore appear that 8.3 per cent. of the total car mileage, or 117,287,407 miles, was absolutely unnecessary. It is impossible to calculate the cost of this enormous empty movement, but that it was a heavy drain on the already depleted revenues of the railroads, cannot be denied. It may be claimed that the saving made by individual roads in per diem balances justified the expenditure which this excess empty movement entailed, but the fallacy of this claim is apparent in the face of the fact that the gain by one line was necessarily offset by the loss to another. Further, in a majority of cases, the movement resulted in practically an even exchange of cars.

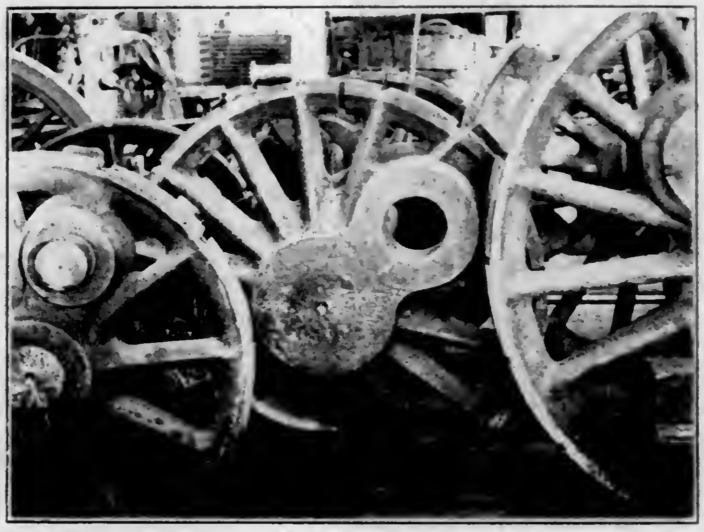
Nor was this wasteful empty movement the only deplorable result of the unfortunate position in which the railroads found themselves. In the efforts to keep per diem balances on the proper side, a great many roads took extreme measures to reduce the number of foreign cars on their lines and to force their own cars into service. Roads which had during the period of shortage, gladly accepted cars belonging to affiliated lines, revised their rules when cars became plentiful and refused to accept cars not properly routing over their lines. Foreign cars were in many instances stopped at junction points and their lading transferred to home cars. In other cases home cars were applied on loading to foreign lines, while foreign cars were sent home empty in the same direction.

There is one encouraging sign in the situation created by the extraordinary developments of the past few months. It is that the experience gained at such great cost may lead to the adoption of more flexible rules governing the use of freight cars in interline traffic. To the extent that such rules recognize the necessity for free interchange of cars, with such regulation as the principle of private ownership demands, to that extent will the future efficiency of freight cars be increased.—*Irving Hale, Chairman, Committee on Car Efficiency, Am. [illegible] Association.*

TURNING DRIVING WHEEL TIRES.

It is often necessary to change an[illegible] en- gine two or three times between shoppings. When [illegible] are sent to the shop for re-turning, the usual practice is [illegible] them on an old pair of wheel centers, mounted [illegible] turn them in the driving wheel lathe. The cost of the labor and gasoline for shrinking the tires on and removing [illegible] considerable. One shop has found that it could handle the tires at about one-half of the cost of turning them in this way by turning them, one at a time, on a boring mill. The mill was an old one and not equipped with a universal chuck.

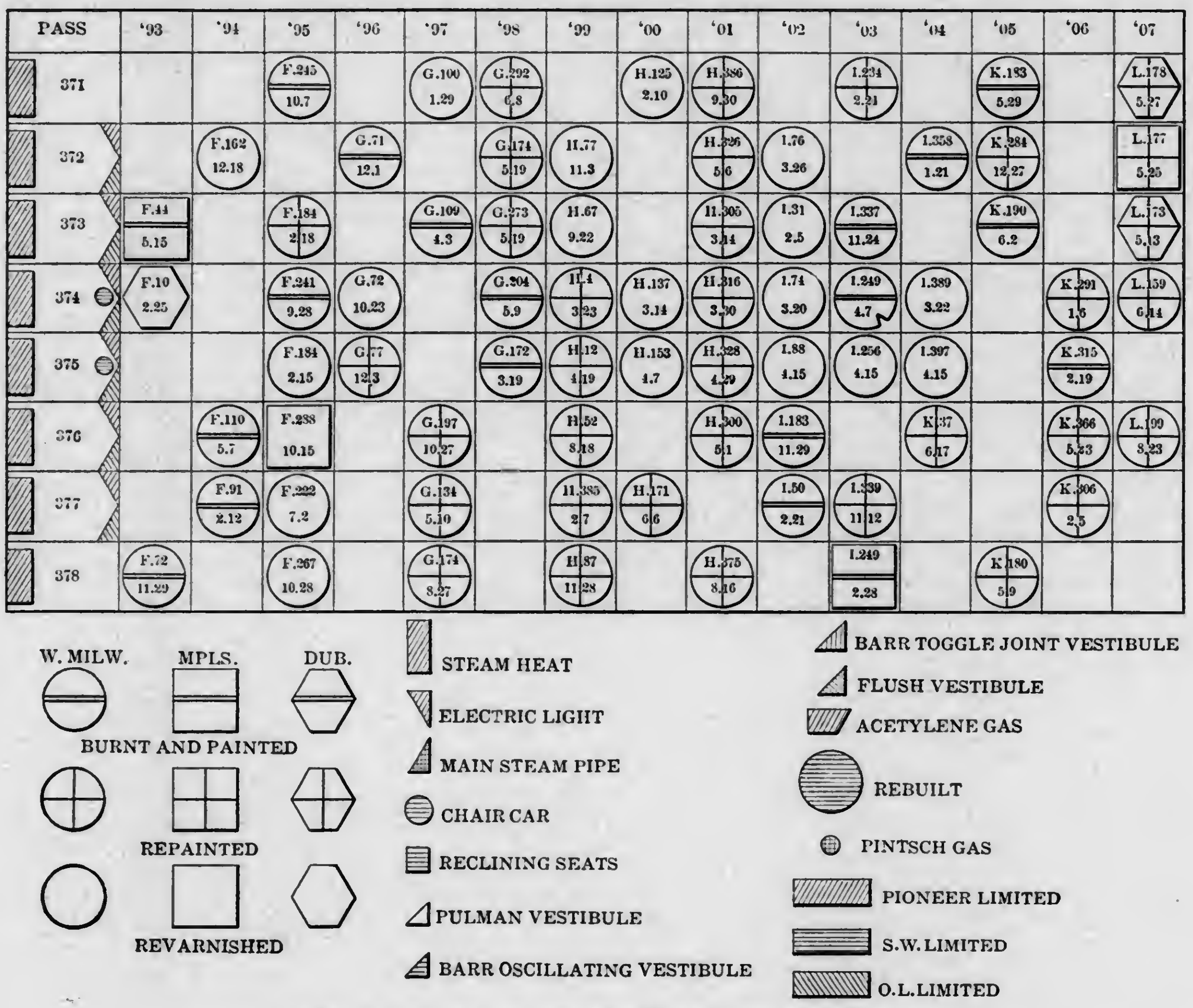
At the St. Paul shops of the Great Northern Railway a still



MANDRELS FOR TURNING TIRES.

different method is followed. Old driving wheel centers for 48, 56 and 66 in. wheels are mounted on scrap axles and turned so that the tires will slip over them neatly. Taper key ways are slotted in the circumference about 18 in. apart. When the tire is slipped on the center, taper keys (1/16 in. to 1 ft.) are driven in, thus holding the tires securely in the centers. The slot and the keys are tapered so that the face of the key and the inside of the tire are parallel when the key is driven tight. They are then turned in the wheel lathe. Only a few minutes are required to set the tires on the centers and the arrangement is said to be very satisfactory. Three sets of these mandrels are all that are required to take care of the greater proportion of the driving wheels in use on the Great Northern; the mandrels when not in use are stored alongside the lathe. A partial view of these mandrels is shown in the accompanying illustration.

RELATIVE USE OF STEAM, WATER POWER, ETC.—Of the total estimated power at present produced by prime movers in this country, about 26,000,000 horse power is produced by steam engines, 3,000,000 horse-power by water motors and 700,000 horse-power by gas and oil engines.—*H. St. Clair Putnam before the Conference on the Conservation of Natural Resources.*



A PORTION OF COACH PAINT SHOP RECORD BOARD—C. M. & ST. P. RY.

COACH PAINT SHOP RECORDS.

CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.

In the coach paint shop office of the Chicago, Milwaukee & St. Paul Railway, at West Milwaukee, is a series of three or four large boards, about 5 x 8 ft. in size, upon which is shown, in a simple manner, the paint and varnish record of each coach for the past fifteen years. These charts also give information as to some of the important features of the equipment of each car. It is possible to determine quickly the approximate present condition of any coach, and, if it is desired, to refer to the book records for a detail description of what was done to the car at each shopping.

The accompanying illustration, showing a small section of one of these boards or charts, will give an idea as to its arrangement. The number of the car is shown in the column to the left. The vertical divisions are for the different years, each one of the spaces being about ⅞ of an inch square. The tags which are tacked on the board are colored, but as it is impossible to reproduce these colors on the illustration the different tags are distinguished by markings shown in the key at the bottom of the diagram. The actual tags are made of mounted drawing paper painted with a flat oil paint to prevent an early fading of the color.

The painting is done at three shops, West Milwaukee, Minneapolis and Dubuque. To distinguish between the shops at which the work is done the round tags represent West Milwaukee, the square, Minneapolis, and the hexagonal, Dubuque. The heavy repairs in painting are divided into three grades: "burnt and painted," which means painting from the bare wood up; "repainting," which means painting on old paint; "revarnished," which means that the paint has been touched up and varnish applied. The key underneath the diagram shows how these three classes of repairs are distinguished apart. As an example, car 376 was burnt and painted at the West Milwaukee shops in 1894; in 1895 it was revarnished at Minneapolis; in 1897, 1899 and 1901 it was repainted at West Milwaukee, and in 1902 it was burnt and painted at West Milwaukee; in 1904, 1906 and 1907 it was repainted at West Milwaukee. Special tags are used for new cars, upon which the name of the builder and the date the car was placed in service are noted.

The notation at the top of each tag shows the book and page upon which a detail record of the work done on the coach may be found; the lower figures indicate the month and date when the car left the shop and was placed in service. To illustrate, the following records are reproduced for car 374, except that a letter of the alphabet is substituted for the name of the varnish used.

F-241.

Arrived August 3, 1895.
Left September 28, 1895.
Body outside; old paint burnt off; two coats priming; two coats body color; one coat varnish body color; ornamented; two coats "A" body varnish.
Inside varnished.

H-4.

Arrived February 28, 1899.
Left shops March 23, 1899.
Body outside; one coat body color; one coat varnish body color; ornamented; one coat "B" medium body varnish; one coat "B" wearing body varnish.
Inside revarnished in part.

I-74.

Arrived February 26, 1902.
Left shops March 20, 1902.
Body outside; five lineal feet new sheathing; 16 battens; 16 ft. window stool, two panels applied; new parts painted; balance paint touched up, whole body two coats of "C" body varnish.
Inside revarnished in part and part finished in shellac.

I-249.

Arrived March 2, 1903.
Left shop April 7, 1903.
Body outside, paint burnt off in part; new sheathing applied throughout; two coats priming; two coats body color; one coat varnish color; ornamented; two coats "C" body varnish.
Inside revarnished in part and part finished in shellac.

I-389.

Arrived February 23, 1904.
Left March 22, 1904.
Body outside; body color cut in; sign board recolored; ornamented in part; whole body two coats of "A" body varnish.
Inside revarnished in part and polished.

In addition to these records a ledger is kept in which the exact cost of the work for each shopping is shown for each car. The page in this ledger for car 374 is as follows: For obvious reasons the figures showing the costs are fictitious and the trade name of the varnish is represented by a symbol.

PASSENGER CAR 374 FROM DAYTON, O., 11-1-88.

Burnt and Painted	A, 9-28-95	F-241	$192.12	2 "A" Body Varnish
Revarnished..........	A, 10-23-96	G- 72	127.70	2 "C" " "
Burnt and Painted	A, 5- 9-98	G-204	759.50	1 Med. and 1 W. B. "B" Varnish
Repainted..............	A, 3-23-99	H- 4	295.41	do
Revarnished..........	A, 3-14-00	H-137	236.26	do
Repainted.............	A, 3-30-01	H-316	301.14	do
Revarnished..........	A, 3-20-02	I - 74	206.33	2 "C" Body Varnish
Burnt and Painted	A, 4- 7-03	I -249	247.92	do
Revarnished..........	A, 3-22-04	I -389	205.18	2 "A" Body Varnish
Repainted..............	A, 1- 6-06	K-291	211.21	1 Med. and 1 W B. "B" Varnish
Repainted..............	A, 6-14-07	L-159	177.85	2 "A" Body Varnish

Tags notched at the lower right hand corner indicate that the car has received new sheathing. The tags in the space occupied by the car number give information as to the equipment of the car, the key to this information being shown below the diagram or chart. For instance, car 374 is equipped with steam heat, as shown by the rectangular tag at the left; is a chair car, as indicated by the small circle at the right of the number; is equipped with electric lights, as shown by the triangular tag in the upper right hand corner, and has a flush vestibule, as shown by the tag at the lower right hand corner. The cars on the "Pioneer" Limited," "Southwest Limited" and "Overland Limited" trains are indicated by large rectangular tags.

These boards occupy very little space, as they are placed one behind the other and are hung from above with counter weights, so that the front ones can easily be raised in order to examine the others. After they are once arranged very little time is required to keep them up to date and it is possible to determine almost at a glance the approximate condition of any car, and with a very few minutes study to determine the general condition of an entire class of cars. A similar board, but more complicated, is maintained in the upholstering department.

We are indebted for information to J. J. Hennessey, master car builder, and Albert T. Schroeder, master painter, under whose direction these charts have been established and maintained.

HORSE-POWER TO DRIVE MACHINE TOOLS.—A good rule for the horse-power required to drive machine tools is to estimate one horse-power for every 10,000 square inches of belt delivered to the machine per minute. This rule is based on a working belt pull of 39.6 lb. per inch of width tending to rotate the pulley, a rule which is justified by the author's experience, and which may be demonstrated as follows: 10,000 square inches of belt per minute = 10,000 linear inches of belt 1 in. wide per minute = 10,000 ÷ 12 linear feet of belt 1 in. wide per minute.

As each inch of width is assumed to carry 39.6 lb. of effective tension, the power transmitted will be:

$$\frac{10{,}000}{12} \times 39.6 \text{ foot-pounds.}$$

$$= \frac{396{,}000}{12} = 33.000 \text{ foot-pounds.}$$

$$= 1 \text{ horse-power.}$$

$$\text{or H. P.} = \frac{\pi\, d\, w\, n}{10{,}000},$$

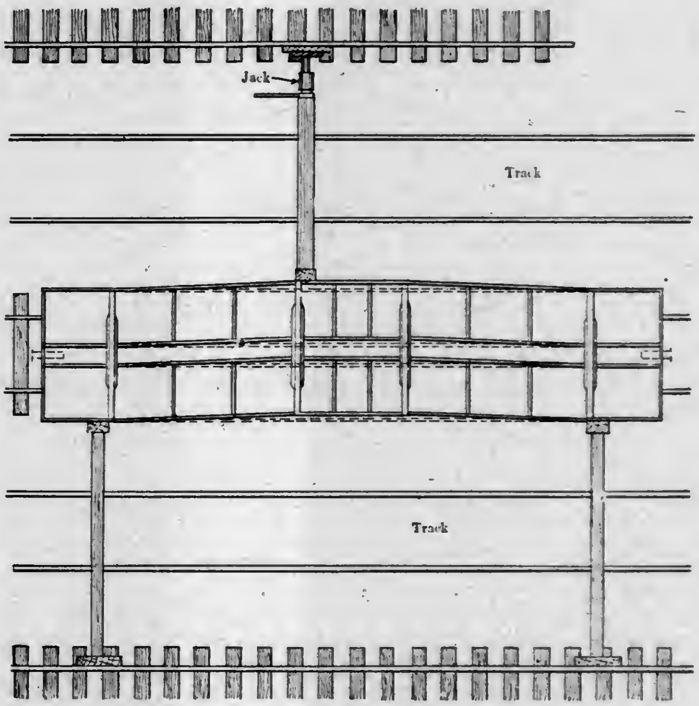
where d = diameter of pulley in inches, w = width of belt in inches, n = turns of pulley per minute.

A tight double belt may transmit twice the amount of power given by the above rule; but although the machine must be strong enough to resist the extra pull, yet it is not wise to provide for double the motive power where separate motors are used, as most motors will stand as much temporary overload as a belt, and no belt will work well long with a permanent overload. —*P. V. Vernon in The (London) Engineer.*

METHOD OF STRAIGHTENING STEEL FRAMES OF WOODEN FREIGHT CARS.

The Rock Island Lines have received, during the past year or two, a large number of freight cars of various types having steel frames. In most cases both the upper and underframes are of steel. It has been found that when these cars are cornered, turned over, or severely treated they will sometimes remain bent and out of line, instead of springing back or breaking in two, as would be the case with wooden cars.

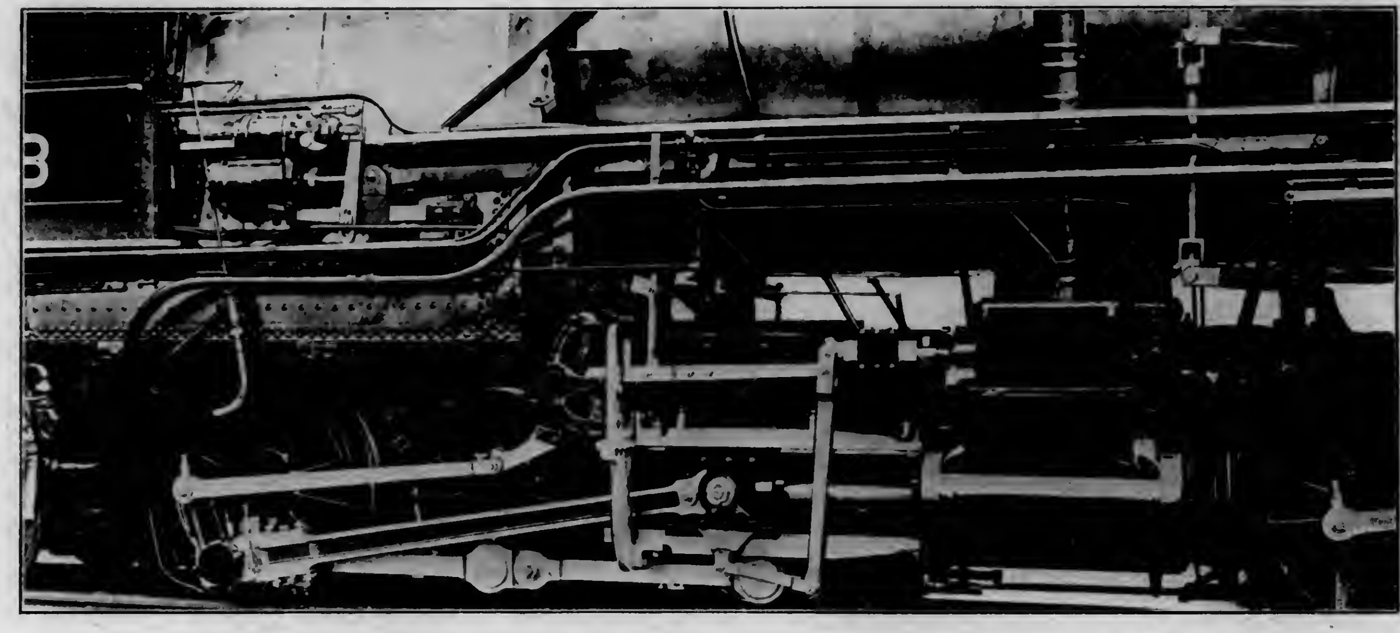
In many cases these distorted frames may be straightened, without cutting the car apart and without stripping, by jacking it back to its original lines. Where a jacking frame, specially made for this purpose, is not available it has been found that the jacking may be accomplished by placing the car so that a footing can be had for the jacks against adjacent tracks, as shown in the accompanying illustration. In some instances distorted underframes have been straightened out by this method at an expense of not over $2.00.



It is not considered necessary or advisable to heat the members of these steel frames for straightening unless the bends are at least 90 degs. The fact that the frames are distorted is not due to weakness or poor design, but registers the fact of their having received unfair treatment, remaining bent instead of springing back or breaking, as is the case with wooden cars. We are indebted for this information to C. A. Seley, mechanical engineer of the Rock Island Lines.

ACCIDENTS ON RAILWAYS.—It is true in the last year, where full returns are available, that 418 passengers were killed on American railroads; it is, however, equally true that we carried 815,778,700 passengers who were not killed. There were 11,185 passengers injured in the same period, 6,778 in train accidents; but again 815,762,933 passengers were carried a little over 25,000,000,000 miles without injury. With these figures I will leave you to the privilege of finding out how many times and how far you can ride on our trains without endangering your life or limb.—*C. E. Lee, Genl. Supt., B. & M., before the New England Railroad Club.*

WOOD FOR PAPER.—The amount of wood consumed in this country for pulp for paper has increased from 2 million to 3½ million cords per year, since 1899. Spruce is the best wood and furnishes about 70 per cent. of the pulp used. The total value of the wood consumed for this purpose in 1906 was $26,400,000.

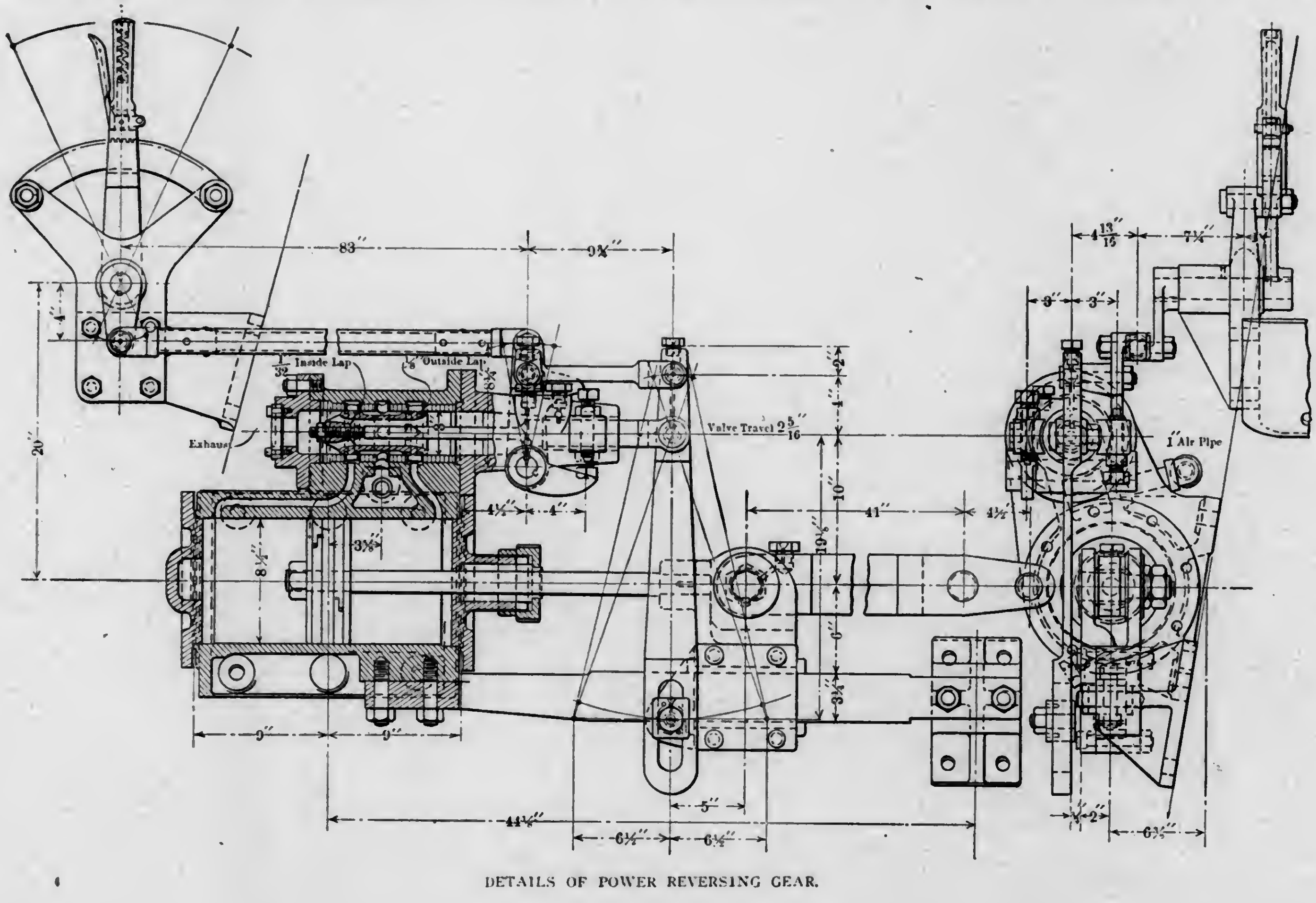


POWER REVERSING GEAR ON MALLET COMPOUND LOCOMOTIVE—GT. NORTHERN RAILWAY.

A POWER REVERSING GEAR.

The Mallet type locomotive requiring, as it does, two complete sets of valve gear makes some sort of a power reversing gear practically compulsory. Several different designs of mechanism for this purpose have been illustrated in the columns of this journal, among which was one, known as the M'Carroll (October, 1906, page 375), applied to the very large locomotives built in 1906, by the Baldwin Locomotive Works, for the Great Northern Railway. Recently a much simpler machine for performing the same work has been designed by the builders and applied to one of these locomotives. It, in general, follows a design which has been very extensively used on marine engines for the same purpose. While railroad and marine service differ in many ways, there would seem to be no important reason why this type of reversing gear could not be made to perform as satisfactory service in the former as in the latter case.

The illustrations show the arrangement and construction clearly and it will be seen that it consists of an 8½ in. air cylinder, the piston in which is connected to a cross head, sliding on a single bar guide. The cross head is connected to the lift shaft by a suitably arranged link. The movement of the piston in the cylinder is controlled by a 3 in. inside admission, piston valve, arranged to give a 1/32 in. inside and ⅛ in. outside lap. The piston valve stem is connected to a combination lever extending vertically from the cross head to which it has a slotted connection. It is also connected by means of a suitable link to the operating lever in the cab. This latter connection is above that



DETAILS OF POWER REVERSING GEAR.

of the valve stem. A rocker is interposed in the connection of the operating lever to the combination lever, which is provided with safety arms, striking adjustable studs, for preventing a movement of the valve beyond the limit of its travel.

The operating lever in the cab is locked in place by a latch and a notched quadrant, and when it is in its central position, with the piston also in the central position, the piston valve will cover both cylinder ports. When, however, the operating lever is moved forward the combination lever swings around its connection to the crosshead as a fulcrum and the valve is moved backward, thus admitting air back of the piston. This then moves ahead and the crosshead carrying the combination lever, which now moves about its upper connection as a fulcrum, carries the valve ahead until it has again reached the central position and cuts off the supply of air. Thus as the operating lever in the cab is moved forward, the piston, and hence the valve gear, follows its movement closely and whenever it is stopped the reversing gear also stops. The gear is so adjusted that when the link blocks have been shifted to the desired cut-off a slight further movement of the piston in this direction will move the valve sufficiently to admit air pressure to the opposite side of the piston and thus lock it securely in place.

PNEUMATIC DRILL TESTER, OMAHA SHOPS, UNION PACIFIC RAILROAD.

PNEUMATIC DRILL TESTER.

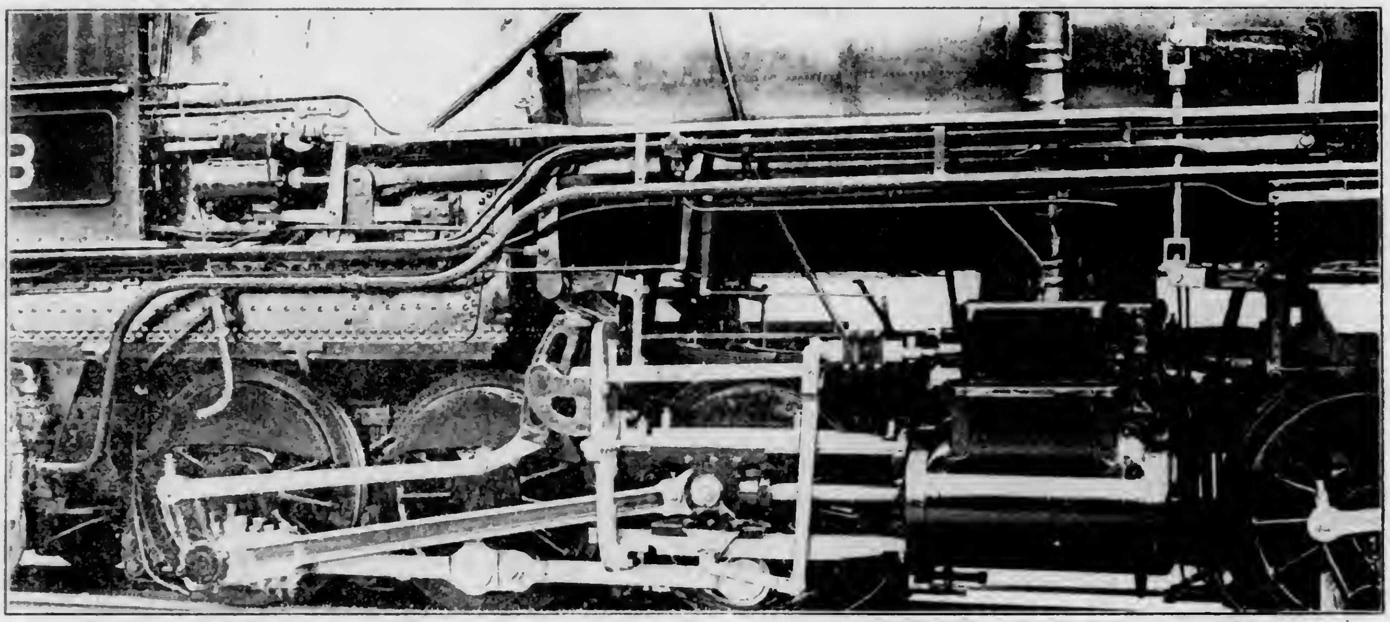
In the September, 1907, issue of this journal, page 364, a pneumatic drill tester was described in which the drill was arranged to drive a fine thread screw, with a piston at its lower end, into a cylinder partially filled with oil. The comparative value of the drill was judged by the pressure on the oil when it was stalled.

A more elaborate and satisfactory device, in use in the shops of the Union Pacific Railroad at Omaha, is shown in the photo. The drill socket engages with the prony brake shaft and the body of the drill is kept from revolving by the two arms projecting from the work bench. The amount of air used by the drill is measured by the "Excelsior Aerometer" at the left, which was supplied by G. D. Warren & Co., of Denver, Colo. An air gauge, not shown in the illustration, shows the air pressure. The speed of the drill may be determined by applying a speed indicator to the rear end of the prony brake shaft. Pressure is transmitted from the prony brake shaft to the small oil cylinder, and is shown by the gauge at the right. The supply of oil in the small cylinder may be replenished from the larger cylinder, at the rear, by operating the large screw.

The efficiency of the pneumatic drill is determined by the prony brake pressure and the amount of air used for a given time when the drill is operating at its normal speed. The ultimate capacity of the drill, or its efficiency at any speed, may also be determined, if desired. All of the pneumatic drills in the shop are expected to be turned in once a week, when they are examined and tested, and if found deficient in any respect are repaired. By systematically caring for the drills it has been found that they give far better results in the shop, and that the maintenance cost is greatly reduced. This testing machine was devised by W. H. Anderson, foreman of the air brake and brass department, and by Gus Lawson, one of the machinists in that department.

New York to Chicago by Trolley.—Some interesting facts are given in the Chicago *Tribune* by the representative of that paper, who recently made the trip from New York to Chicago by trolley. In all he traveled a distance of 1,278 miles, 936 of which were covered on the trolley and 339 on the steam roads. The time spent on the trolley was 42 hours and that on the steam cars 10½ hours. The cost in fares was $23.55, of which $15.22 was paid to the electric railways and $8.35 to the steam roads. The average rate on the electric lines was 1.6 cents per mile; that on the steam lines 2.4 cents per mile. The longest unbroken run by trolley was from Lafayette, Ind., to Westfield, N. Y., a distance of 595 miles. Strangely enough, the longest steam runs were made getting out of Chicago and into New York. The former was 74 miles and the latter about 89 miles. There are only two breaks in the line between Chicago and Buffalo, but there are four between Buffalo and New York.—*Street Railway Journal.*

Growth of Electrically Applied Power.—Of the total 30,000,000 horse-power, including the railroads, used in this country, it is estimated that 9,000,000 horse-power, or 30 per cent., is now utilized electrically. This remarkable growth was accomplished in twenty-five years. The use of electric power at the present time is being doubled approximately every five years, as contrasted with the phenomenal doubling of the total power every ten years. If the present rate of increase is maintained, electrically applied power will equal or exceed the power mechanically applied in 1920. The significance of this remarkable increase in the use of electric power in manufactures and other industries lies in the market thus provided for the utilization of our water powers wherever located and whatever their magnitude.—*H. St. Clair Putnam before the Conference on the Conservation of Natural Resources.*

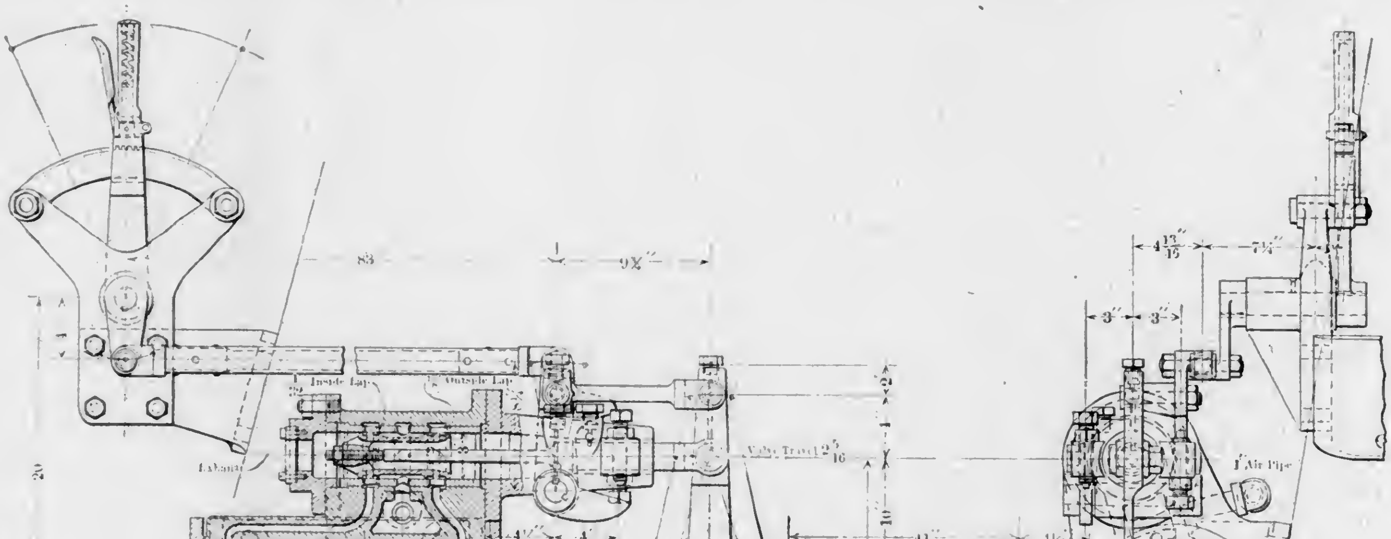


POWER REVERSING GEAR ON MALLET COMPOUND LOCOMOTIVE—GT. NORTHERN RAILWAY.

A POWER REVERSING GEAR.

The Mallet type locomotive requiring, as it does, two complete sets of valve gear makes some sort of a power reversing gear practically compulsory. Several different designs of mechanism for this purpose have been illustrated in the columns of this journal, among which was one, known as the M'Carroll (October, 1906, page 375), applied to the very large locomotives built in 1906, by the Baldwin Locomotive Works, for the Great Northern Railway. Recently a much simpler machine for performing the same work has been designed by the builders and applied to one of these locomotives. It, in general, follows a design which has been very extensively used on marine engines for the same purpose. While railroad and marine service differ in many ways, there would seem to be no important reason why this type of reversing gear could not be made to perform as satisfactory service in the former as in the latter case.

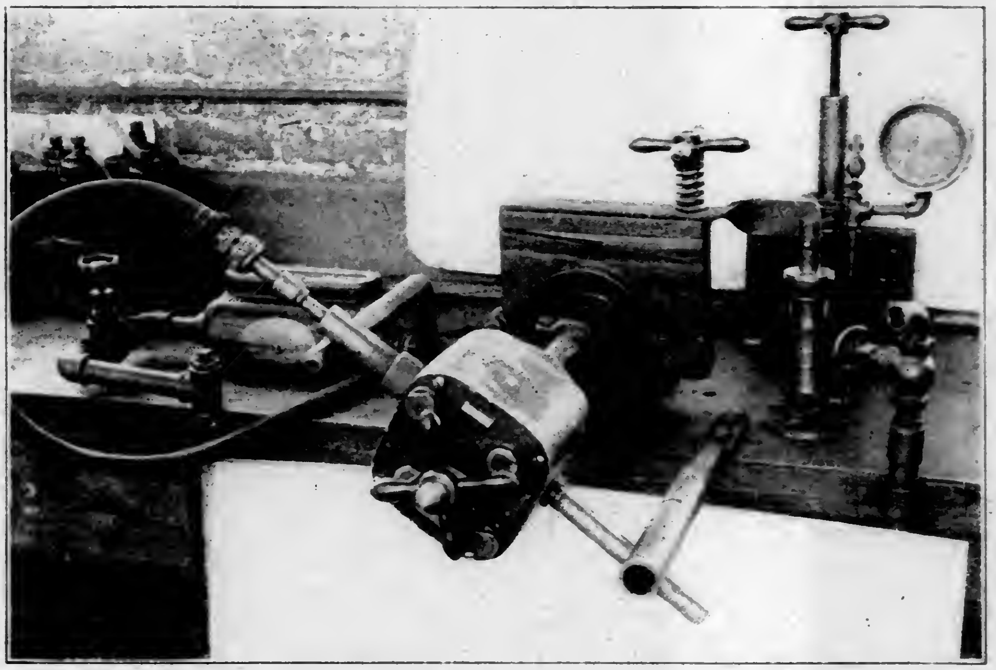
The illustrations show the arrangement and construction clearly and it will be seen that it consists of an $8\frac{1}{2}$ in. air cylinder, the piston in which is connected to a cross head, sliding on a single bar guide. The cross head is connected to the lift shaft by a suitably arranged link. The movement of the piston in the cylinder is controlled by a 3 in. inside admission, piston valve, arranged to give a 1/32 in. inside and $\frac{1}{8}$ in. outside lap. The piston valve stem is connected to a combination lever extending vertically from the cross head to which it has a slotted connection. It is also connected by means of a suitable link to the operating lever in the cab. This latter connection is above that



DETAILS OF POWER REVERSING GEAR.

of the valve stem. A rocker is interposed in the connection of the operating lever to the combination lever, which is provided with safety arms, striking adjustable studs, for preventing a movement of the valve beyond the limit of its travel.

The operating lever in the cab is locked in place by a latch and a notched quadrant, and when it is in its central position, with the piston also in the central position, the piston valve will cover both cylinder ports. When, however, the operating lever is moved forward the combination lever swings around its connection to the crosshead as a fulcrum and the valve is moved backward, thus admitting air back of the piston. This then moves ahead and the crosshead carrying the combination lever, which now moves about its upper connection as a fulcrum, carries the valve ahead until it has again reached the central position and cuts off the supply of air. Thus as the operating lever in the cab is moved forward, the piston, and hence the valve gear, follows its movement closely and whenever it is stopped the reversing gear also stops. The gear is so adjusted that when the link blocks have been shifted to the desired cut-off a slight further movement of the piston in this direction will move the valve sufficiently to admit air pressure to the opposite side of the piston and thus lock it securely in place.



PNEUMATIC DRILL TESTER, OMAHA SHOPS, UNION PACIFIC RAILROAD.

PNEUMATIC DRILL TESTER.

In the September, 1907, issue of this journal, page 364, a pneumatic drill tester was described in which the drill was arranged to drive a fine thread screw, with a piston at its lower end, into a cylinder partially filled with oil. The comparative value of the drill was judged by the pressure on the oil when it was stalled.

A more elaborate and satisfactory device, in use in the shops of the Union Pacific Railroad at Omaha, is shown in the photo. The drill socket engages with the prony brake shaft and the body of the drill is kept from revolving by the two arms projecting from the work bench. The amount of air used by the drill is measured by the "Excelsior Aerometer" at the left, which was supplied by G. D. Warren & Co., of Denver, Colo. An air gauge, not shown in the illustration, shows the air pressure. The speed of the drill may be determined by applying a speed indicator to the rear end of the prony brake shaft. Pressure is transmitted from the prony brake shaft to the small oil cylinder, and is shown by the gauge at the right. The supply of oil in the small cylinder may be replenished from the larger cylinder, at the rear, by operating the large screw.

The efficiency of the pneumatic drill is determined by the prony brake pressure and the amount of air used for a given time when the drill is operating at its normal speed. The ultimate capacity of the drill, or its efficiency at any speed, may also be determined, if desired. All of the pneumatic drills in the shop are expected to be turned in once a week, when they are examined and tested, and if found deficient in any respect are repaired. By systematically caring for the drills it has been found that they give far better results in the shop, and that the maintenance cost is greatly reduced. This testing machine was devised by W. H. Anderson, foreman of the air brake and brass department, and by Gus Lawson, one of the machinists in that department.

New York to Chicago by Trolley.—Some interesting facts are given in the Chicago *Tribune* by the representative of that paper, who recently made the trip from New York to Chicago by trolley. In all he traveled a distance of 1,278 miles, 936 of which were covered on the trolley and 339 on the steam roads. The time spent on the trolley was 42 hours and that on the steam cars 10½ hours. The cost in fares was $23.55, of which $15.22 was paid to the electric railways and $8.35 to the steam roads. The average rate on the electric lines was 1.6 cents per mile; that on the steam lines 2.4 cents per mile. The longest unbroken run by trolley was from Lafayette, Ind., to Westfield, N. Y., a distance of 595 miles. Strangely enough, the longest steam runs were made getting out of Chicago and into New York. The former was 74 miles and the latter about 89 miles. There are only two breaks in the line between Chicago and Buffalo, but there are four between Buffalo and New York.—*Street Railway Journal.*

Growth of Electrically Applied Power.—Of the total 30,000,000 horse-power, including the railroads, used in this country, it is estimated that 9,000,000 horse-power, or 30 per cent., is now utilized electrically. This remarkable growth was accomplished in twenty five years. The use of electric power at the present time is being doubled approximately every five years, as contrasted with the phenomenal doubling of the total power every ten years. If the present rate of increase is maintained, electrically applied power will equal or exceed the power mechanically applied in 1920. The significance of this remarkable increase in the use of electric power in manufactures and other industries lies in the market thus provided for the utilization of our water powers wherever located and whatever their magnitude.—*H. St. Clair Putnam before the Conference on the Conservation of Natural Resources.*

(Established 1832).

AMERICAN ENGINEER AND RAILROAD JOURNAL.

PUBLISHED MONTHLY

BY

R. M. VAN ARSDALE

140 NASSAU STREET, NEW YORK

J. S. BONSALL,

Business Manager.

R. V. WRIGHT,
E. A. AVERILL, } Editors.

JULY, 1908

Subscriptions.—$2.00 *a year for the United States and Canada;* $2.50 *a year to Foreign Countries embraced in the Universal Postal Union. Remit by Express Money Order, Draft or Post Office Order. Subscription for this paper will be received and copies kept for sale by the* Post Office News Co., *217 Dearborn St., Chicago, Ill.* Damrell & Upham, *283 Washington St., Boston, Mass.* Philip Roeder, *307 North Fourth St., St. Louis, Mo.* R. S. Davis & Co., *346 Fifth Ave., Pittsburg, Pa.* Century News Co., *6 Third St., S. Minneapolis, Minn.* W. Dawson & Sons, Ltd., *Cannon St., Bream's Buildings, London, E. C., England.*

Advertisements.—*Nothing will be inserted in this journal for pay,* EXCEPT IN THE ADVERTISING PAGES. *The reading pages will contain only such matter as we consider of interest to our readers.*

Contributions.—*Articles relating to Motive Power Department problems, including the design, construction, maintenance and operation of rolling stock, also of shops and roundhouses and their equipment are desired. Also early notices of official changes, and additions of new equipment for the road or the shop, by purchase or construction.*

CONTENTS

* Illustrated articles.

CONVENTION NOTES

Young's Million Dollar Pier formed an ideal place for holding the convention. The weather was propitious and the exhibits were all under cover and were placed to much better advantage than in previous years. The attendance at the conventions was 10 per cent. greater than last year and the exhibits occupied 7 per cent. more floor space.

* * * * * * *

A pastor of one of the Atlantic City churches had been invited to open the Master Mechanics' convention with a prayer. For some reason he was unable to be present and J. H. Setchell was called upon to perform this duty. The force of the brief petition thus offered by one of the members of the association—"one of us"—as a member said—was felt by all present and made a very strong impression. Prayers which have been made at some of the previous conventions often indicate that the speaker is not well informed, or is not in touch with the work of the association, and as a result the effectiveness of the prayer is often lost. It is to be hoped that those in charge of the program for future conventions will delegate this duty to members of the associations.

* * * * * * *

Each year a protest has gone up because of the late date at which the advance copies of the convention reports are sent out to the members, but unfortunately the conditions seem to get worse each succeeding year. It is time that the executive committes of the two associations took some decided step in this matter. The discussions at the conventions show quite clearly that the members are not afforded time to digest their reports. On large systems the reports should be received in time so that the superintendent of motive power, or mechanical superintendent, could call a meeting of his assistants and subordinates and carefully discuss the reports and decide upon the best action to be taken by its representatives at the convention. In one instance a time had been set for such a meeting, but the reports were received so late that it was necessary to call it off. One superintendent of motive power received the reports only two hours before he started for the convention. It should be distinctly understood that the delay in issuing these reports is through no fault of the secretary, Mr. Taylor; indeed it is a wonder that he is able to get them out at all considering the late date at which some of them are turned over to him by the committees in charge. If it was not for his resourcefulness and hard work some of the reports would never have reached the last convention in printed form.

* * * * * * *

One feature of the exhibits was the large number of machine tools which were displayed. Most of them were shown in operation, driven by individual electric motors, and were grouped by themselves, in a well lighted pavilion. Those in charge of these exhibits expressed themselves as well pleased and they will undoubtedly return another year. Several machine tool manufacturers who did not exhibit have decided to do so next year and in one or two cases have even gone so far as to apply for space at the next convention. It is too bad other technical associations cannot arrange to meet at the same place and about the same time as the railroad mechanical conventions in order to take advantage of such exhibits.

* * * * * * *

The committee on subjects of the Master Car Builders' Association is to be congratulated upon the wise step which they took in suggesting only a very few subjects for the next convention, thus allowing more time for the consideration of the reports of the standing committees. The work of these standing committees is so important and so extensive that nothing should be allowed to interfere with having it properly presented and discussed by the members. It has been suggested that both the Master Mechanics' and Master Car Builders' Associations might do well to pattern after the American Railway Engineering and Maintenance of Way Association and have more than one session a day. The present single session is very long and better results and much more work could be accomplished by having two shorter sessions.

MASTER CAR BUILDERS' ASSOCIATION

FORTY-SECOND ANNUAL CONVENTION.

The first session of the 42nd annual convention of the Master Car Builders' Association was called to order on Young's Million Dollar Pier at Atlantic City, on June 17, 1908, the president, George N. Dow, being in the chair. Following a prayer by the Rev. Newton D. Caldwell, the Hon. F. P. Stoy, mayor of Atlantic City, welcomed the association in a brief address, to which reply was made for the association by Eugene Chamberlain.

The address of the president drew attention to the work which the present convention should attend to, as well as indicated general lines of progress that should be followed in the future. He stated that the two great objects of the association were, first, to promote uniformity in car construction and, second, to secure the most economical results in the interchange of traffic between the railroads of the country. These are so closely related as to compel the careful observance of the standards of the association if the best results are to be obtained in interchange. He drew attention to the careful scrutiny which the standards of the association are being given by the operating officials and to the great importance that they should be given the very closest attention. Some of the recommendations which the president wished to draw to the attention of the members are best given by quotations from his address as follows: "The necessity for co-operation and co-ordination of the work of the various railway associations has led the American Railway Association to propose changes in its organization which will admit of more harmonious relations between the various railway associations, and at the same time tend to centralize the recommendations for authoritative action with that association. In view of the nature of a great deal of the work of the Master Car Builders' Association, it is important that this association co-operate to the fullest extent with the American Railway Association, and in order that this may be accomplished some change in the constitution and by-laws of the Master Car Builders' Association will be necessary.

"The constitution at the present time does not provide for filling vacancies which may occur in the office of the president and vice-president or members of the executive committee, except by election at the convention, nor is it required that these officers of the association and members of the executive committee should actually be engaged in the railway service. I would therefore recommend that the constitution be changed to cover these points, after the subject is given full consideration by the proper committee.

"In the past, a large list of subjects has been referred to the association, and in the future, I would recommend reducing the list so as to give better opportunity to investigate and discuss the subjects more thoroughly.

"The adoption of a standard M. C. B. coupler. Several years ago an ineffectual effort was made in that direction. I believe the time is now ripe for such action.

"There has been a steady increase in the use of steel in car construction. The steel car has come to stay and I believe this association should give attention to this important matter to the end that its use may be extended more and more. I would recommend the appointment of a committee on standard steel shapes.

"Several years ago the question of the adoption of standard dimensions for the box car recommended by the American Railway Association was considered, and a system of framing only was accepted. The question was not given the consideration it deserves and to my mind is one that should be revived and studied to a conclusion. This subject at that time was referred to us by the American Railway Association, and we should complete our work and carry out the instructions given us. The appointment of a committee on this subject should be considered by your executive committee."

The report of the secretary showed the total membership to be 726, of which 424 were active members, 275 representative, 13 associate, and 14 life members. The number of cars represented in the association was 2,283,330, an increase of 28,933 for the year. The report showed that during the year twenty-nine railroads and private car lines had signified their desire to become subscribers to the rules governing interchange of freight cars. Five railroads had also advised of their acceptance of the code of rules governing the interchange of passenger equipment. The dues for the year 1909 were fixed at $4.00 per vote.

The address of E. A. Moseley, secretary of the Interstate Commerce Commission, received the closest attention. Mr. Moseley drew attention to the new employer's liability law passed by the recent Congress, which greatly increases the financial responsibility of interstate carriers to their employees and makes it necessary for them to exercise the greatest care in the employment of men, as well as in keeping all equipment in proper repair.

Attention was drawn to a decision rendered in the Supreme Court, which held that the variation in the height of couplers is downward from 34½ in., so that draw-bars on standard gauge freight cars must not be higher than 34½, nor lower than 31½ in. to comply with the law. Another principle of fundamental importance in connection with this case was the decision, in unmistakable language, that the statute imposed upon common carriers the absolute duty of keeping their equipment in the condition required by law at all times and the exercise of reasonable care in this respect was no defence.

Mr. Moseley drew attention to the legislation now pending before the Congress which aims to make the standards of the M. C. B. Association for the protection of trainmen the law of the land. This goes to indicate the great importance of the standards of the association and emphasizes the care with which they should be adopted.

Prosecutions for the violation of the safety appliance law to the number of 2,260 were filed in court during the preceding year. Mr. Moseley stated that the general condition of equipment throughout the country now showed such marked improvement that he believed the time was near when these appliances would be kept in the best possible condition and that the necessity for prosecution would be eliminated.

Following this address, the secretary announced that the executive committee submitted to the association for approval for honorary membership, the name of A. G. Steinbrenner, who had been a member of the association since 1883. This membership was approved.

The secretary announced that certain proposed amendments to the constitution had been received and would be sent to the members before the end of the year. The chair was authorized to appoint a sub-committee of three members of the executive committee of the association to confer with the proper committee of the American Railway Association and report to the executive committee so that the recommendations as to changes in the constitution and by-laws, necessary to secure greater co-operation between the American Railway Association and other railroad associations, might be distributed to members before December 15, 1908.

Revision of Standards and Recommended Practice.—The report of this committee was read by C. A. Seley in the absence of the chairman, T. S. Lloyd. The report was very complete and practically all of the recommendations of the committee were ordered to be submitted to letter ballot. In addition to these a suggestion by O. C. Cromwell in regard to the joining of the taper to the straight portion at the center of axles, which had been disapproved by the committee, was approved and ordered to be submitted to letter ballot. An appendix to the committee report, regarding the size of brake shoe hangers and the design

of heavier springs under truck bolsters for 100,000 lb. capacity cars, was read by Mr. Seley. The suggestions by John McE. Ames in regard to flooring, shown on sheet M. C. B. 24, and by Mr. McKeen, concerning an error in drawing on M. C. B. sheet 9, and of Mr. Gibbs concerning the welding of brake shafts, were all approved and ordered to be submitted to letter ballot.

TRIPLE VALVE TESTS.—The report was read by Mr. Pratt, received and the committee continued.

BRAKE SHOE TESTS.—The report of the committee was read by Dr. Goss, who also submitted a criticism from F. W. Sargent concerning the designation of brake shoes in the report of the test and suggesting that they be designated by trade names rather than by the marking on the shoe. The report was briefly discussed by Mr. Sanderson and Mr. Muhlfeld, the latter offering a motion that the committee's report be accepted and that it be given the necessary additional facilities for carrying out its work and be requested to submit a proposed specification covering the items of material reinforcement, test and limits of allowable wear which will cover the most suitable brake shoe for steel tired and cast iron wheels in passenger and freight service under the different braking pressures. This motion was carried.

TEST OF M. C. B COUPLERS.—The report of the committee was presented by Mr. Curtis, who drew attention to some slight changes made in the diagram showing the bracket for the uncoupling lever, which accompanied the original report. These changes were slight and have been made for the purpose of avoiding some patents. The corrected drawing will be shown in the proceedings for the year. Mr Curtis emphasized the necessity for very close inspection of the attachment of the yoke to the butt of the coupler.

Mr. Muhlfeld spoke in favor of the suggested increase in the size of yoke rivets and stated that he believed careful consideration should be given to the use of abutting lugs. His experience in this connection was that it was not necessary to do any machining in order to make a proper fit. Attention was drawn to the advisability of forming the gibs on the coupler yokes by bending instead of upsetting the metal, the former being much stronger as shown by tests. Mr. Muhlfeld moved, which motion was carried later, that this committee be requested to submit recommendations covering a material specification for coupler head castings, which will incorporate the chemistry, or, at least, the maximum allowable limit of certain elements in addition to the minimum allowable cross sectional area of metal between the face and the knuckle lock cavity and at the junction of the guard arm and the body of the coupler head.

Mr. Kleine did not consider it advisable to include a chemical analysis in the specifications. Mr. Fowler was opposed to the including of a chemical analysis in the specifications, as was also Mr. Clark.

R. P. C. Sanderson spoke on the subject of side and bottom operating uncoupling devices, stating that he believed that this matter needed more attention, as he was convinced that it would be necessary to come to this type of operating device before very long. His experience had shown that these uncouplers were satisfactory if properly designed. Mr. Sanderson also spoke at some length in regard to the use of dead blocks, which he believed would soon come into general use, especially with steel cars. He reported a number of tests that had been made and showed a diagram from a compression test of an oak block, which very closely approached that of a good friction draft gear.

Mr. Hennessey regretted that the committee did not give greater attention to the side and bottom operating couplers, since this type is now practically a standard on some roads.

Mr. Brazier stated that he hoped members would make experiments with the side operating coupler, with a view of seeing if better results could not be obtained than with the overhead type.

Mr. Marden (Boston and Maine) spoke in favor of the side uncoupling device, and also of the use of dead blocks. His experience with the latter had been very satisfactory.

Mr. Stark, a member of the committee, was not in favor of embodying a chemical analysis in the specifications and did not believe that side operated couplers would be satisfactory. He stated that the committee had in mind the tests suggested by Mr. Sanderson and were planning to make them during the coming year.

Mr. Schroyer stated that the great cause of breakage of links and clevices is the fact that they are made of malleable iron. He was not in favor of a specification which embodied a chemical analysis, believing that a physical test was all that was needed. He spoke in favor of wooden dead blocks on cars.

Mr. Gaines spoke in favor of the dead block.

The report of the committee was then accepted and its recommendations were ordered to be referred to letter ballot.

ARBITRATION COMMITTEE.—The decisions of this committee were formally accepted by the association and suggestions for changes in the rules, which were given in a supplementary report, were also approved.

REVISION OF RULES FOR LOADING LONG MATERIAL.—The report of this committee recommended that the rules for loading long material should be advanced from recommended practice to standard. This suggestion was referred to letter ballot, as were also the other recommendations of the committee.

CAST IRON WHEELS.—The report of this committee was, in the absence of Mr. Garstang, presented by Mr. Lockwood, who stated that the report was not signed by the entire committee and that Mr. Muhlfeld wished to present a minority report. This minority report was then presented and after a short discussion the subject was recommitted to the committee.

A motion was made by Mr. Crawford to the effect that the opening in the gauge for condemning M. C. B. standard wheels be changed from 1 1/16 to 1 in. for wheels under cars of 80,000 and 100,000 lbs. capacity and be changed from 1 in. to 15/16 in. for wheels under cars of less than 80,000 lbs. capacity. This motion was carried.

JOURNAL BOX AND PEDESTAL FOR PASSENGER CARS WITH 5 x 9 AND 5½ x 10 IN. JOURNALS.—The report of this committee was presented and referred to letter ballot.

MARKING OF FREIGHT EQUIPMENT CARS.—The report of this committee was presented and referred to letter ballot.

AIR BRAKE HOSE SPECIFICATIONS.—The report of this committee was received and the committee continued.

On motion of Mr. Stark the matter of air brake hose in connection with the rules of interchange was referred to the executive committee with power to change the rules, in respect to hose, according to its best judgment in the matter and the date for putting these rules into effect should be changed to Sept. 1, 1909.

AUTOMATIC CONNECTORS.—The report of the committee on this subject was presented and the committee was continued with instruction to investigate further.

LATERAL BRACING OF STEEL FREIGHT CARS.—The report of this committee was received and the committee continued to investigate the service conditions relative to steel underframe and all steel cars and attempt to decide on some general specification for the application of a lateral bracing, especially between the body bolster and end sill.

SIDE BEARINGS AND CENTER PLATES FOR FREIGHT AND PASSENGER CARS.—The report of the committee was presented by Mr. Sanderson and a minority report by Mr. Crawford. Mr. Muhlfeld spoke in favor of the minority report. No action was taken on the recommendations and the committee was continued and instructed to conduct laboratory and service tests of antifriction center plates and side bearings.

STEEL PASSENGER CARS.—The report of this committee was presented but the lateness of the hour prevented any discussion.

HEATING AND VENTILATING PASSENGER CARS.—The report was presented by S. G. Thompson, chairman, and on motion was received with the thanks of the association.

PROTECTIVE COATINGS FOR STEEL CARS.—The report of this committee was presented by G. E. Carson, chairman, was received and the committee continued.

LOCATION OF ENDS OF RUNNING BOARDS.—The committee on this subject presented a brief progress report, which was received and the committee continued.

STANDARDS FOR THE PROTECTION OF TRAINMEN.—The report of this committee was presented by C. A. Seley, chairman, who

drew attention to some minor changes that had been made in the wording of the report as originally sent out.

A motion by Mr. Brazier, amended by Mr. Sanderson, was carried, which stated that the report be accepted and referred to the executive committee; that the corrections recommended be made and suggestions from members as to modifications in the recommendations be considered by the executive committee if received before July 6, 1908, and that the report in its corrected form should be submitted to letter ballot.

The motion was then carried directing the executive committee to appoint a standing committee on "standards for the protection of trainmen."

BOX CAR DOORS AND FIXTURES.—The report of this committee was presented and the committee continued to consider suggestions which were made during the discussion and to report again next year.

The discussion of this report was on the construction of the bottom door guide bracket, which was believed to have too large an extension: the securing of the door hangers and the securing of the hand holds to the door. Also the connection of the door hasp catch and the protection strip on the bottom of the door, which was not believed to be heavy enough.

TANK CARS.—The report of this committee was presented by A. W. Gibbs, chairman, who also recommended that the appendix be included with the rest of the report. The motion was carried that the report of the committee, including the appendix, should be received and referred to letter ballot. The committee was continued.

SUBJECTS.—The report of this committee was received and referred to the executive committee for consideration.

ASSOCIATE AND LIFE MEMBERSHIP.—The name of Dr. Charles H. Benjamin, Dean of the School of Engineering, Purdue University, was approved for associate membership by the executive committee and notice was given that a vote would be taken on this proposal a year hence.

The executive committee approved the applications for life membership of W. H. Thomas and C. H. Cory, who joined the association in 1888.

TOPICAL DISCUSSIONS.—On account of the shortness of time and the great importance of the reports of standing committees, practically all of the topical discussions, which were assigned to different members, were not reached, and permission was given to such members to submit what they desired to say on the subject in writing, for the purpose of including it in the printed proceedings. There were no discussions on any of the topical discussions, with the exception of the one on the limits of the length of journals, which will be reviewed next month.

ELECTION OF OFFICERS.—The election of officers for the ensuing year resulted as follows:

President, R. F. McKenna, M. C. B., D. L and W. R. R., Scranton, Pa.

1st Vice-President, F. H. Clark, G. S. M. P., C. B. & Q. R. R., Chicago, Ill.

2nd Vice-President, T. H. Curtis, S. M. P., L. & N. R. R., Louisville, Ky.

3rd Vice-President, Le Grand Parish, S. M. P., L. S. & M. S. Ry., Cleveland, O.

Executive Committee, J. E. Muhlfeld (B. & O.), C. E. Fuller (U. P. R. R.), H. D. Taylor (P. & R. R. R.), J. F. Walsh (C. & O. Ry.) and C. A. Schroyer (C. & N. W. R. R.)

ABSTRACTS OF COMMITTEE REPORTS

Air-Brake Hose Specifications.

Committee—Le Grand Parish, chairman; J. Milliken, R. W. Burnett, J. A. Carney, R. F. Kilpatrick.

In 1906 the committee made recommendation that a chemical test be incorporated in the specifications for air-brake hose. It has been found, however, that this is not practicable and we therefore withdraw this recommendation.

As the wrapped air-brake hose specifications are now the standard and the woven and combination woven and wrapped specifications are recommended practice, the committee has recommended to the committee on standards and recommended practices that the specifications which are now recommended practice for woven and combination wrapped and woven air-brake hose be advanced to a standard of the Association.

The rules which go into effect September 1, 1908, require the use of standard hose, and unless the specifications for woven and combination wrapped and woven hose be advanced to a standard together with the wrapped hose, the use of this type of hose will not be permitted.

It has been brought to the attention of the committee that, on account of the damage continually done to the nipple end of hose, possibly hose built up by reinforcement or protection at the ends may prove an effective and economical proposition. While the committee has given consideration to this it is not yet in a position to make more definite recommendation than to emphasize the necessity of maintaining the present specifications another year.

Tank Cars.

Committee—A. W. Gibbs, chairman; C. M. Bloxham, W. McIntosh, S. K. Dickerson, F. T. Hyndman.

At the 1907 convention the paragraph relating to the axle requirements and the stenciling of the tank cars with light weight and capacity or light weight and maximum weight was discussed and some exceptions taken. The opinion was expressed that such markings would bring about complications with the traffic rate schedules based upon a weight per gallon and the capacity of the car in gallons, but it was considered essential that some maximum or limit weight marking should be placed upon tank cars to enable inspectors to determine whether the strength of axles and trucks were sufficient to carry the load. This resulted in the following motion being carried at the convention: That the recommendation of the committee be accepted and referred to letter ballot, eliminating the capacity of the cars, the amendment being proposed by Mr. Crawford and accepted by Mr. Schroyer: That the proposition should be submitted to letter ballot under two headings.

The following questions were submitted to letter ballot and both failed to receive the necessary two-thirds vote:

89. Tank car specifications, including provision for stenciling light weight and capacity.

90. Tank car specifications, excluding provision for stenciling light weight and capacity.

It is quite evident that the two questions as appearing in letter ballot did not cover the views of the members as expressed in the discussion, namely, that light weight and capacity markings were objectionable from a traffic schedule standpoint and that a maximum weight was necessary to enable inspectors to determine the strength of axles and other parts of trucks.

A further canvass of the situation has been made and it is found from a traffic viewpoint that there are no objections to stenciling tank cars "Limit Weight," which will afford inspectors all the necessary information from a safety standpoint, but will have absolutely no bearing on the traffic question of how much is lading and how much is car.

This will involve some change in the requirements for tank cars as submitted last year relating to axles, besides which it is desirable to make slight modifications in some of the other detail requirements to bring them up to date.

[Changes recommended in the report not reproduced.]

The committee would recommend that the following specifications be submitted to letter ballot for adoption as recommended practice:

1. Tank car specifications, with the exception of axle requirements, presented last year with the modifications suggested in this report, it being understood that the axle requirements and stenciling limit weight will be voted upon separately.

. Axle requirements with the provision that the tank cars be stenciled *Limit Weight.*

Lateral Bracing of Steel Freight Cars.

Committee—R. B. Kendig, chairman; W. F. Bentley, W. F. Eberle, W. T. Gorrell, F. W. Dickinson.

The work of the committee on this subject was outlined by the committee on subjects at last year's convention in the following manner:

"The majority of wooden cars have no diagonal bracing in the underframing, depending on bolted joints and connections to keep the bodies square. In the case of a severe shock a wooden car will spring and give, but return to its former lines, while cars of steel or composite construction, on account of inability to spring after a severe shock, will remain sprung and bent out of line. The same committee to investigate the design of the upper framing of box cars."

A circular of inquiry met with response representing 40 per cent. of the total number of cars represented. The information elicited shows such a marked division of opinion and practices

that the committee does not feel competent to present a recommendation on lateral bracing for steel cars which would probably be acceptable even to a small minority of the Association.

After defining the term lateral bracing to mean either gusset bracing at the connection of bolster and longitudinal sills, or diagonal struts, between the bolster and end sill, it developed that no steel underframe cars were reported without lateral bracing in one form or another. Different designs of cars require different treatment as to their lateral bracing, so that it would be impossible to design a bracing arrangement suitable for application to all classes of cars.

Concerning the upperframing of box cars, below are quoted two replies received in answer to the question as to what is considered the essential features in the design of framing of superstructure for steel box cars. These replies are fairly representative of all the suggestions offered, either one of which has considerable merit.

"I would consider as an essential feature in the design of steel underframing the use of standard sections, angles, channels, and 'Z' bars, with as simple and direct connection to sills and plates as possible. I would tie the corner members back with metal girths to all side members extending back to door posts. I would consider the side framing as carrying its proportion of the lading and structure, and proportion the members accordingly. I would give the end lining full bearing against the end framing, which would be moderately heavy and well secured and thereby resist the shocks of shifting loads. It is well-nigh impossible to do this in wooden car construction, and one of the strongest points for steel superstructure is in the above advantage."

"A light frame steel side with riveted gusset connections at the corners and junctions of diagonal braces with posts and sills. On account of its depth this side truss can be required to carry a considerable portion of the load to the bolster, which will deliver it direct to the center plates. It is desirable to have this steel framing exposed, use no outside sheathing, but double lining of say 1¾-inch tongue and grooved timber carriage bolted to steel frame. The ends of the car must be of fairly heavy steel construction, also made of 1¾-inch inside lining, flashing to be used at the top of the lining to insure watertight joints. Steel carlines and light steel plate roof protected from damage by boards above."

There were only four roads reported as having experience with metal upperframing for box cars, and in consequence the committee does not feel that a conclusion can be drawn from the experience obtained from these examples which would warrant it in presenting a standard design of upperframing for the consideration of the association.

The committee does not believe that the work delegated to it by the association can be accomplished with any degree of satisfaction at the present time and therefore recommends its discharge.

Steel Passenger Cars.

Committee—A. M. Waitt, chairman; W. R. McKeen, Jr., T. Dunbar, J. McE. Ames, C. A. Lindstrom, W. B. Ott, R. L. Gordon.

The committee appointed to report upon steel passenger cars was directed by the executive committee of the Association to investigate that subject and advise the Association on the following five headings:

1. To consider the question generally, *i. e.*, as to what is being done in this direction.
2. To recommend a standard sectional area for the center sills and cover plates.
3. To consider the relative merits of steel passenger cars with upper decks and those with a semi-elliptical section without an upper deck.
4. To consider the best construction of flooring.
5. To consider the relative merits of various materials for inside finish for fireproof construction.

General History up to 1908.

The consideration of a change in the construction of passenger equipment cars in this country from what has been termed "wood construction" to "metal construction" has been brought more prominently before the railroad world during the last six to eight years, although the possible use of metal for such purposes was considered many years before, for we find that as early as 1854 designs of passenger cars were prepared by Mr. B. B. Lamothe, in which the superstructure was of metal but the end and sills remained of wood. Very little progress, however, was made until about 1902, when the question of the use of metals was prominently brought forward, due to various causes, among which may be mentioned as the most important:

(a) The burning of wooden cars in wrecks, and frequent destruction of human life by fire:

(b) The splintering of the large wooden sills, etc., when cars were wrecked, causing injury and death:

(c) The scarcity of lumber suitable for sills, stringers, etc., and the threatened exhaustion of such material.

While these three conditions are most important, there are a number of other reasons for the use of steel which may be mentioned, as, for instance:

(d) In collision with wooden freight cars the passenger equipment had some chance to escape from total destruction, but with the very large increase of steel freight cars this opportunity does not longer exist;

(e) Increased speeds, greater train length, and larger capacity of cars. Although the wooden cars have been improved by increasing the strength of parts affected by the pulling and buffing stresses, by the use of metal platforms, the application of vestibule buffers, etc., yet these expedients are little better than makeshifts.

In 1902 the rapidly increasing use of electric motor cars caused Mr. George Westinghouse to call attention to the dangers of fire incident to the use of electric power, and to suggest the use of non-inflammable materials, especially in cars for elevated and subway service, where it would be difficult for passengers to leave the cars rapidly. The accident in the Paris subway some years ago illustrates what may happen. Brief references to electric and other motor cars is, therefore, considered essential in this report, as the construction of these cars has had an important influence in the development of steel passenger car construction, and unquestionably the knowledge and experience obtained in the building of such cars, together with the satisfactory results derived from the use of steel freight cars, has been largely responsible for what is now being accomplished with passenger equipment cars generally.

In addition to this, with the increased requirements of thickly populated districts and the rapid development of electric and other power for transportation, the average motor car has grown to such proportions that to-day it approaches closely the average steam car, and there are, even now, some cars in service which have been designed to meet the requirements of both steam and electric service.

In 1902, the Illinois Central Railroad Company and the Pressed Steel Car Company, each independent of the other, started to prepare designs embodying the use of steel in passenger cars.

The design prepared by the Illinois Central Railroad[1] was utilized in the building of some composite steel cars with side doors, the first cars being ready for service during the summer of 1903. It is generally supposed that the appearance of these cars started the era of steel passenger car construction in this country.

The design prepared by the Pressed Steel Car Company embodied the use of steel in the underframe and trucks only, as it was thought that a gradual introduction of steel would meet with more favor than a radical change. This design was submitted to several railroad officers, but while some thought that steel would eventually have to be used and the constructions were in the right direction, others thought it was too far advanced for present requirements; and, again, others thought it did not go far enough and that, when a change was made, the upper framing as well as the under frame should be made of steel. The result of the various opinions was that no cars were built.

In 1903, the Pressed Steel Car Company built for the Northwestern Elevated, of Chicago, thirty-five pressed steel underframes for elevated service. The superstructure of these cars was built by the St. Louis Car Company, and was of wood. These underframes were constructed of two inverted pressed steel fish-belly-shaped side sills, 17 inches deep at the center and 10 inches deep over the bolsters. The balance of the underframes being made of pressed parts and rolled shapes, no truss rods were used, as the side sills were of sufficient strength to carry the lading. The inverting of the sills made them invisible from the outside, and the appearance of the cars was the same as the ordinary wooden car. These cars are giving very good satisfaction in service.

Following this the committee presented brief descriptions of the following all-steel cars: Interborough,[2] 1904; the Erie Railroad baggage car and the New York, New Haven & Hartford Railroad postal and express car, 1904; New York Central[3] motor car, 1906; Southern Railway[4] composite car, 1906; Pennsylvania Railroad[5] steel cars, 1906; Harriman Lines[6] cars, 1906; Long Island Railroad[7] passenger car, 1906; Santa Fe[8] postal car, 1905; St. Louis and San Francisco paggenger car, 1907.

Motor Cars.

A design of car which has been developed in the last few years and is now receiving a great deal of attention, is the Union Pacific[9] gasoline motor car, built by the Union Pacific Railroad at its Omaha shops. Some twenty of these cars are now in ser-

[1] See American Engineer, June, 1903, page 204; September, 1903, page 327, and October, 1903, page 359.
[2] American Engineer, October, 1904, page 375.
[3] American Engineer, March, 1907, page 81.
[4] American Engineer, July, 1906, page 260.
[5] American Engineer, April, 1907, page 136, and June, 1907, page 232.
[6] American Engineer, January, 1907, page 6, and December, 1907, page 464.
[7] American Engineer, February, 1907, page 41.
[8] American Engineer, October, 1906, page 397. (Steel Underframe.)
[9] American Engineer, August, 1905, page 294; November, 1905, page 420; May, 1906, page 187.

vice, and a number more are being constructed; and, aside from the mode of propulsion, they embody some very distinct departures from the old construction of railroad cars.

The upper deck and deck sash have been replaced by semi-circular roof, and thereby a reduction of 24 inches in overhead clearance is obtained. The ends of the car are so constructed as to reduce the wind resistance as much as possible. The conventional rectangular windows are replaced with round metal sash 24 inches in diameter. Another noticeable feature in these cars is the absence of vestibules and steps at the ends of the car and the introduction of side doors at the center. The cars are practically all-steel.

A general idea of the extent to which the all-steel principle is being applied to this class of equipment may be obtained from the following statement. This statement is not necessarily complete, but covers all the different motor type of cars of which the committee could learn:

Road.	No. Cars.	Service.	Built.
Inter. Rapid Transit Co.	300	Subway Electric	1904
Long Island R. R. Co.	134	Suburban Electric	1905
New York Central R. R. Co.	125	Suburban Electric	1906
Hudson Terminal Company	50	Subway Electric	1907
C. R. I. & P. R. R.	1	Motor for Surface Tracks	1907
D. L. & W. R. R. Co.	1	Motor for Surface Tracks	1907
Inter. Rapid Transit Co.	50	Subway Electric	1907
N. Y. & Queens County R. R.	40	Trolley Electric	1907
Union Pacific R. R.	20	Gasoline Motor for Surface Tracks	1906-7
Boston Elevated	45	Electric Elevated	1907
Phila. Elec. Elevated Ry.	80	Elevated and Subway Electric	1906
Union Pacific R. R.	22	Gasoline Motor (under construction)	

PULLMAN COMPANY—STEEL SLEEPING CAR.

The designing and construction of an all-steel sleeping car presents a somewhat more difficult problem than that of an ordinary coach. Nevertheless, the Pullman Company has given the matter considerable study and attention during the past few years, and early in 1907 completed an experimental car, "The Jamestown."[10] This car was also, to a certain extent, an exhibition car, and it was one of the efforts of the builders to produce, as nearly as possible, a composite steel car without suggesting in its appearance the use of steel.

EUROPEAN STEEL CAR CONSTRUCTION.

One of the members of this committee had the opportunity to spend a couple of months in Europe this last winter, which time was partly devoted to the examination of a number of car works in England, France, Germany, Sweden, Austria and Hungary, with a view to learning European practices in regard to the building of steel cars, so that the benefit of such investigations would be available to the Master Car Builders' Association in this report.

These investigations revealed that while steel underframe cars have been in use in Europe for forty or fifty years, or perhaps longer, there are very few passenger cars being built in any of the shops visited in the various countries enumerated, in which passenger cars were built, with steel upperframes as well as with steel underframing, the general practice being to place a wooden body on a steel underframe and cover the outside of the body with 1-16-inch steel plates, which gives the appearance of a steel car, these steel cover plates being secured with small screws to the wooden posts, sill and braces.

The underframe is constructed in numerous ways, some being of the fish-belly type, made either in pressed steel or of plates and angles, and the other types being usually "I" beam or channel side sills held from deflection by means of truss rods in the way usual on wooden cars. The construction of these underframes is, however, of such nature, due to the quite different way in which the draft riggings are applied to European cars, that nothing of importance can be learned from them, the draft arrangements being of the continuous type and the buffing stresses being taken on side buffers. These cars have no heavy center sill construction, as is required on American cars, where not only the pulling, but also the buffing stresses are generally taken by the center sills.

A notable feature in connection with European cars is that all trucks, whether four-wheel or six-wheel, used on the later equipment, are made of steel, no wooden trucks being used. The steel trucks are of various constructions, but the majority are of pressed steel of either the Fox type or types resembling the Fox. A number of trucks are, however, in use in which the side framing and cross framing are composed of "I" beams, channels and angle irons.

As far as could be learned by conversation with engineers and builders of railroad cars, no consideration or study is being given to the development of an all-metal passenger car, and no attempt is even being made to utilize the steel plates on the outside to carry part of the lading, the total load being carried on the underframe, regardless of the construction of the upper framing.

GENERAL REMARKS.

The development of a steel passenger car from what has been said in regard to what is being used abroad, may be considered an American innovation of the last few years. On account of the lack of available data the progress has necessarily been slow, and generally of what may be called an experimental nature.

[10] AMERICAN ENGINEER, April, 1907, page 130.

The development in steel motor cars seems to have been more rapid than in steel railway cars. This is probably due to the fact that the service in which the motor equipment is used is such as to make protectionary measures against injury from fire of primary importance; whereas, with the steam cars the development seems to have been retarded for the same reasons which were advanced against the steel freight cars when they were first introduced—*i. e.,* first cost, excessive weight, difficulties of repairs, corrosion, etc., limiting the life of the cars. These objections have, however, been—through the experience obtained with steel freight cars—practically eliminated; as, for instance, the cost, which was the feature given the most consideration, is now not so important as the question of providing a car sufficiently strong for the service regardless of a somewhat increased first cost.

The increased cost of a steel passenger car over a wooden car of the same general construction and size, and with the same specialties, should not be very great when a number of cars of the same design and general type are built. The few, of what may be called sample cars of steel, enumerated above, which have been built in the past, have, of course, been very costly as compared with wooden cars, but this has been due to the great cost of getting up designs, appliances, etc., for their manufacture, all of which will be greatly reduced in the future, and especially on larger orders for cars. It should always be borne in mind when the use of steel cars is contemplated, that such cars may be obtained at very much less cost if some type of car is decided upon, of which cars have already been built, instead of making new designs, often embodying a number of changes more or less important, which in many instances could be dispensed with.

The question of weight of steel passenger cars was perhaps the next important consideration, but from what has already been accomplished the problem seems to have been solved, and if proper care is exercised in the design, so as to place the material in the car to the best advantage for strength, etc., there is no reason at all why the construction of cars containing all-steel, or steel and partly non-inflammable material, cannot be produced, which cars would be much stronger than wooden cars, and with practically no increase of weight per passenger as compared with the wooden cars of the same general type and capacity.

In the table below is given a comparison between some typical wooden coaches with three of the all-steel design of coaches, and this comparison shows quite favorably for the steel car when the column giving weight per passenger is considered, and this is the only true basis for consideration. It is possible that still better results may be obtained in the future without the sacrificing of strength.

Class or Number	Road	Material	Length Over Body Feet	Seat Capacity	Weight	Weight per Passenger	Weight per Foot
290-295	Lehigh Valley	Wood	70	77	118,000	1,530	1,685.7
1015-51	Frisco	"	70	80	106,200	1,327	1,517.1
P. L.	Pennsylvania	"	70	80	106,000	1,325	1,514.3
1st Class	N. Y. C. Lines	"	61	76	92,800	1,221	1,521.3
P. K.	Pennsylvania	"	53.75	62	85,000	1,373	1,581.5
Average			64.95	75	101,600	1,355.4	1,563.9
P-70	Pennsylvania	Steel	70.75	88	116,100*	1,319	1,652.6
Coach	South. Pacific	"	60	70	107,000†	1,528	2,546.6
Coach	Union Pacific	"	68	78	89,300†	1,145	1,313.2
Average			66.25	78.6	104,133	1,330.6	1,837.04 6

* Includes storage batteries. † Includes storage batteries and axle generators.

The life of steel passenger cars is yet to be determined, but judging from experience obtained abroad with steel underframes in passenger cars, which, as stated before, have been in use for some forty to fifty years, and some of which have been in service for twenty-five to thirty years, as well as from the experience already obtained in this country with steel freight cars, some of which were placed in service as early as 1884 and are still in service, it would seem that a carefully designed and constructed steel passenger car, in which the tendency toward loose rivets will be reduced to a minimum, should last a great number of years, depending upon how long a structure of this kind can be preserved with paint and other means of preventing corrosion. It is generally supposed that passenger cars of steel will receive better attention than freight cars, at least such has been the experience with the wooden car equipment. The rivet work, is, however, a feature which should receive special attention, for if the construction is such as to permit vibration or deflection, producing undue stresses not anticipated or provided for, trouble may be expected.

It is also felt that the rivet heads should not be considered as an objection when used in the exterior finish of the car, as they may be neatly arranged with respect to size of heads, location, etc., and, further, to countersink the rivets is objectionable in thin plates on account of decreased strength and liability to work loose; but, on the other hand, rivet heads have been found, in European practice at least, to gather around them a great deal

of dirt, difficult to remove and maintain a good appearance on the exterior of the car. It would therefore be up to the designer, as well as to the users of cars, to decide as to which is the most preferable. European practice seems to favor the use of the countersunk heads where practicable, and the ordinary rivet heads where less objectionable to the finish of the car and where they cannot be successfully avoided without increasing the material or other complications.

Mechanical officers of railroads differ greatly at present as to the best methods in design for overcoming the objectionable features of the wooden passenger cars. Varying local conditions existing on roads on which steel cars have been put in service also had much to do with the widely different forms of design and construction that have so far been made use of in this country.

In a general way, however, the steel equipment already in service can be identified under one of three forms, *i. e.:*

1. Cars with steel underframing and wooden superstructure somewhat similar to the methods employed in modern steel freight car construction in which the underframing is of steel;

2. Cars with steel underframing and steel upperframing, such as posts, braces and carlines; the balance of the material being of wood, or part fireproof material; or, in other words, a "composite" car with perhaps steel on the outside in place of wooden siding;

be anticipated in the construction of the car. This may be due in a measure to a lack of reliable information on just what occurs in collision; but the varying length of train, difference in speeds, and other operating conditions are also elements which must be considered.

There is also a difference in ideas among designers as to how the stresses in a car can best be met, and because of this, together with the foregoing, new cars are being constructed along entirely different lines. These different designs, however, may be divided into three types, to-wit:

First: That in which the load, due to the weight of the car body and lading, is carried by side girders; an additional girder being provided through the center of the car for the pulling and buffing strains. An illustration of this class is the New York Central motor car.

Second: That in which the load, due to the weight of the car body and lading, is carried by the center girder, which at the same time takes care of the pulling and buffing strains. Under this class would come the Pennsylvania Railroad car.

Third: That in which the center and side sills with truss rods and the general construction of wooden cars is reproduced in metal. The Southern Pacific car may be given as an example of this class.

These types of course can, and they do, exist somewhat in

ROAD	No. of Cars	Service	Form	Seat Cap.	Wt. of Truck	Wt. of Body	Total Weight	Wt. per Passenger	Kind of Truck	Length Over Body	Apprx. Date 1st Car in Service	Builder
Ill. Central	17	Sub. Pass	Composite	100	23,200	61,400	84,600	846	4-wheel	65' ½"	Sept. '03	Ill. Cent
Interborough	300	Passenger Electric Tunnel	All Steel	52	13,000 Motor; 9,100 Trailer; 12,600, 2 Motors	41,836	75,596	1,454	4 "	41'	June '04	A. C. & F. Co.
Erie R.R.	1	Baggage	"	.....	40,600	66,080	106,680	.....	6 "	60' 1"	"	Std. S. C. C.
Long Island	134	Passenger Suburban	"	52	14,000 Motor; 9,600 Trailer; 14,430, 2 Motors	45,988	82,138	1,580	4 "	41'	Apr. '05	A. C. & F. Co
Erie R.R.	1	Postal	"	.....	40,600	74,080	114,680	.....	6 "	65' 2"	May '05	"
Santa Fe	39	"	Steel Underframe	.....	.....	.....	105,000	.....	6 "	60' 9¾"	Nov. '05	A. C. & F. C.
Erie R.R.	1	Express	All Steel	.....	40,600	66,080	106,680	.....	6 "	60' 1"	"	Std. S. C. Co.
N.Y.N.H & H.	2	Postal	"	.....	36,000	73,800	109,800	.....	6 "	65' 2"	Apr. '06	"
Southern	3	Pass	Composite	72	36,200	73,600	110,000	1,527.7	6 "	66'	June '06	P. S. C. Co
N.Y.C. & H.R	125	Surburban Passenger	All Steel	64	15,000 Motor; 11,140 Trailer; 12,160, 2 Motors	67,170	105,500	1,648	4 "	50'	"	A. C. & F. Co.
Penna	1	Pass	"	72	25,100	78,450	103,550†	1,438	4 "	58' 5¾"	July '06	P. R. R. Co.
So. Pacific	1	"	"	70	31,500	75,500	107,000‡	1,528	4 "	60'	"	S. P. Ry.
Long Island	1	Sub. Pass	"	72	22,000	66,800	94,500†	1,312	4 "	58' 6"	Sept. '06	A. D. & F. C.
Penna	1	Baggage	"	.....	25,100	67,900	93,000†	.....	4 "	60' 10¾"	Nov. '06	P. R. R. Co.
So. Pacific	1	Postal	"	.....	.....	.....	119,800‡	.....	6 "	60' inside	Apr. '07	S. P. Ry
Pullman	1	Sleeping	"	.....	.....	.....	160,000†*	.....	6 "	72' 6"	"	Pullman.
Hudson Co.	40	Passenger	"	44	13,900 Motor; 9,850 Trailer; 10,400, 2 Motors	40,400	74,550	1,694	4 "	38' 2¼"	May '07	A. C. & F. Co.
U.P. Ry.	1	Postal	"	.....	.....	.....	119,800‡	.....	6 "	60' inside	June '07	U. P. Ry.
U.P. Ry.	1	Pass	"	78	.....	.....	89,300	1,144	4 "	68' over end	Oct. '07	"
Penna	5	Postal	"	.....	39,000	89,500	128,500‡	.....	6 "	71' 4"	Feb. '07	P. R. R. Co.
Interborough	50	Passenger Electric Tunnel	"	48	.....	33,740	78,696	1,639	4 "	39' 2"	Nov. '07	A. C. & F. Co.
Penna	1	Pass	"	88	25,100	91,000	116,100†	1,319	4 "	70' 3¾"	Dec. '07	P. R. R. Co.
Penna	1	"	"	64	25,100	70,300	95,400†	1,490	4 "	53' 5¾"	Mar. '08	"
Frisco	25	Baggage	Steel Underframe, Composite Top	.....	40,300	65,900	106,200	.....	6 "	60' 9½"	Feb. '08	Pullman.
Frisco	6	Mail & Ex.	Steel Underframe, Composite Top	.....	40,300	74,500*	114,800*	.....	6 "	70' 1"	Building	"
Penna	154	Pass	All Steel	88	25,100	91,000†	116,100†	1,319	4 "	70' 8¾"	"	A. C. & F. Co.
Penna	22	Baggage	"	.....	25,100	67,900	93,000†	.....	4 "	60' 10¾"	"	P. S. C. Co.
Penna	10	Dining	"	.....	39,000	101,000*	140,000†*	.....	6 "	71' 4"	"	P. R. R. Co.
Penna	14	Postal	"	.....	39,000	89,500	128,500‡	.....	6 "	71' 4"	"	A.C. & F. Co.
Penna	5	Pass. Bagg	"	42	39,000	81,000	120,000†	.....	6 "	71' 4"	"	P. S. C. Co.
Long Island	50	Sub. Pass	"	72	25,100	50,400*	75,500*	1,049	4 "	54' 3¾"	"	A.C. & F. Co.
Lehigh Valley	15	Express	Steel Underframe	.....	19,000	72,000	110,000	.....	6 "	67' 8"	"	H. & H. Co.

*Estimated.
†Includes storage batteries.
‡Includes storage batteries and axle generator.

Total according to form: 85 Steel underframe. 21 Composite. 275 All Steel. — 380

Total according to service: 230 Passenger. 16 Express. 63 Postal. 49 Baggage. 1 Sleeping. 10 Dining. 11 Combination.

3. All-steel cars—*i. e.,* cars made up of steel or metal throughout, with the possible exception of small quantities of wood and fireproof material for filling blocks, insulation and interior finish, such as mouldings, etc.

In the table given above, is a list of cars already built, or under construction, most of which have been referred to in this report. This table also gives the general forms of construction, weights, etc., together with the approximate order in which the cars were completed or are expected to be in service. In making comparisons between the different types of cars, the weight of storage batteries, generators, etc., which may be used on some cars and not on others, should be taken into consideration.

A summary of the above will show that the steel car equipment for steam railroads now in service or under construction, and coming within the scope of this report, is composed of about 380 units. Nine railroads and four or five car companies figure more or less in the operation and production of these cars. The greatest development is shown in the East, which is no doubt stimulated by the many tunnels in and around New York through which the cars of steam railroads will pass, and in the construction of which cars steel and fireproof material is considered to be essential in order to insure safety.

STANDARD SECTIONAL AREA OF CENTER SILLS.

There appears to be a considerable difference of opinion among railroad men to-day as to what end shocks and stresses should

combination, an example of such combinations being the Erie and Southern cars, where a portion of the load of the car body and lading reaches the trucks through cantilevers and the center sills, while another portion is transferred to the trucks from the sides of the car through the bolsters. The center sills, therefore, resist the end shocks and assist in carrying the load.

The type also influences the weight, but to what extent the disadvantage of increased weight with any one type is offset by other disadvantages of some other type has yet to be determined.

The center sill area of the cars given for illustration is as follows: For the first class 10.66 square inches; for the second, 50 square inches, and for the third, 18.52 square inches.

As will be observed, these areas differ widely, but it is not at all probable that the cars were designed for the same end shock. However, had this been the case, from a careful study of the conditions it is plain that the areas would still have differed; so that from this and so long as cars of these different types are built it is not considered practical to recommend a uniform section of center sill, nor a standard sectional area, as on the disposition of metal in a section largely depends its value.

In addition, before this could consistently be done it would be necessary to standardize the different lengths of passenger equipment cars, and if the three types of construction are to be perpetuated, dispose of the question of straight versus fish-belly center sills and the provision of side doors—in short, the fram-

ing of the car almost as a whole. It is possible, however, to adhere to limiting conditions so that with the use of rational methods of calculation we can accomplish closely the same purpose.

For freight cars it has been the practice for some roads to assume that a car must withstand end shocks equivalent to 300,000 pounds compression whenever the car is shifted, and such shocks are often equivalent to 500,000 pounds. The center sill construction of these cars has been such as to enable it to resist this shock without exceeding the elastic limit of the metal, and from the past five years' experience it is believed that this basis is none too high.

In collisions between passenger and freight cars the passenger cars should not be seriously damaged, which requires the passenger car center sill construction to be at least as strong as that of the strongest freight cars. For passenger cars it is advisable to use a higher factor of safety, therefore the center sill construction in passenger equipment cars used in through trains should be capable of withstanding a shock of 150,000 pounds on the draft gear and 250,000 pounds on the buffers, making a total of 400,000 pounds compression, in which the combined stresses should be 12,500 pounds per square inch, and in no case exceed 15,000 pounds per square inch. For cars used strictly in suburban service—in comparatively short trains with coaches of the same size—the fiber stress might be increased to 20,000 pounds, but this figure should not be exceeded.

UPPER DECKS VERSUS SEMI-ELLIPTICAL ROOFS.

As there is such a radical difference of opinion among the committee as to the relative merits of steel passenger cars with upper decks, and those with semi-elliptical section without upper deck, it seems wise and proper to place before the association the claims of the advocates of each type of roof. For purposes of discussion the subject naturally resolves itself into: (1) relative strength; (2) relative safety; (3) appearances—inside and out; (4) cost and economy; (5) ventilation.

By consultation, a marked difference of opinion of prominent railroad mechanical men and designing engineers has been developed. Some have criticised the semi-elliptical roof, on account of the lack of ventilation and inartistic appearance. Others are strongly in favor of this departure from the upper deck, on account of claimed superior strength, appearance, cheapness and economy of construction, and more particularly on account of its claim for having superior ventilating facilities.

RELATIVE STRENGTH.

The advocates of the semi-elliptical roof argue that the relative strength of such a roof, as compared with a multi-angular double-deck roof, is apparently conclusive as to the superior strength of the semi-elliptical roof. The double deck roof, as Fig. 1, Plate J, illustrates, is composed of six sharp angles—six points where there is practically no elasticity whatever—which is weakening to the structure itself. In addition, at each one of these angles is a joint, a conjunction of parts, an inherent weakness of design.

With the heavier equipment, steel or iron carlines have been introduced to reinforce the wood; but these steel carlines unsupported are extremely fragile, and frequently lose their shape and are often damaged in handling before they can be applied to the cars.

In constructing a new passenger coach, the roof of the car, as generally built, has to be supported from the floor by posts until the sheathing and lining are complete, so as to make it self-sustaining. In the semi-elliptical roof, the posts and carlines are, as a rule, made as one steel unit with no joints; as illustrated by Fig. 2, Plate J, it is claimed of much lighter construction than any wood or combination material ordinarily used in the double-deck type of roof, and extends from one side sill up over the roof and down, joining into the other sill, forming one of the strongest shapes known—self-supporting from the time it is fastened to the side sill, each member reinforcing and adding strength to its additional members; the efficiency and strength of such designs seem obvious to its advocates.

The adherents of the upper-deck type of roof contend that the claims for superior strength in the semi-elliptical roof are based more on theory than any practical proof. It is believed that the style of roof carline used with the upper deck can be made in every way as strong as the carline for a semi-elliptic roof, having the same depth of roof from eaves to crown, or at least practically as strong and without any undue increase in weight. The claim that a roof of semi-elliptical shape is practically non-collapsible, if the car is turned over in a wreck is questioned by its opponents. It is interesting to note that in recent construction on British and European railways the upper-deck type of roof is rapidly superseding the semi-elliptical type wherever the restrictions of tunnels will permit the change. This would indicate that the roads who have longest used semi-elliptical roofs find them less satisfactory than the American upper-deck roof. Some members of the Association are familiar with a large number of passenger cars in the East constructed without any heavy upper-deck sills or plates, but every carline was a through carline so constructed as to be practically free from any weak corners or joints. Decks made in this manner were over 1,000 pounds lighter than the regulation upper deck, and though lighter, much stronger and had less tendency to spread. If an ordinary upper-deck section is framed in like manner to the semi-elliptic roof it is claimed possible to have all the advantages of the upper deck combined with any possible advantages of the semi-elliptic form.

SAFETY.

The advocates of semi-elliptical roofs claim that in case of derailment, the sides of the car are held together with a double-deck roof by such a weak construction, that the superstructure is most generally distorted out of shape, frequently going to pieces

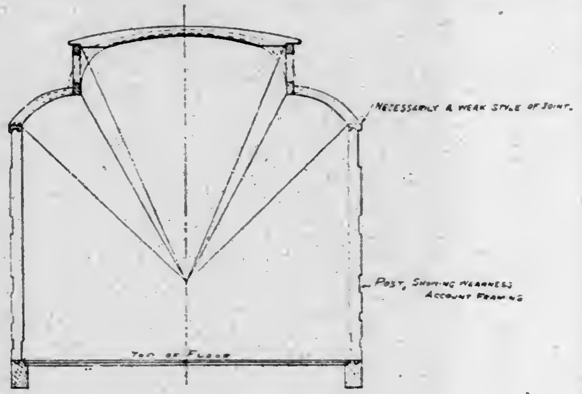


FIG 1.

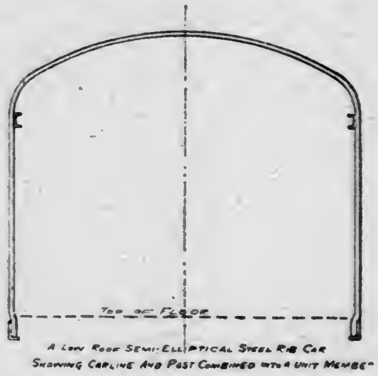


FIG. 2.

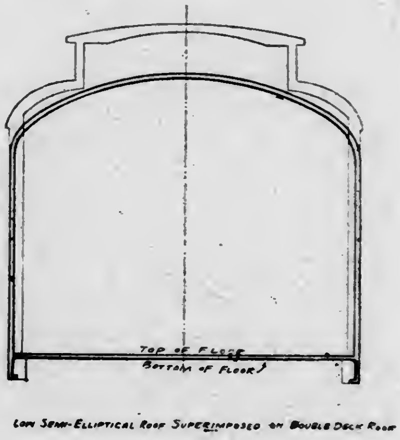


FIG. 3.

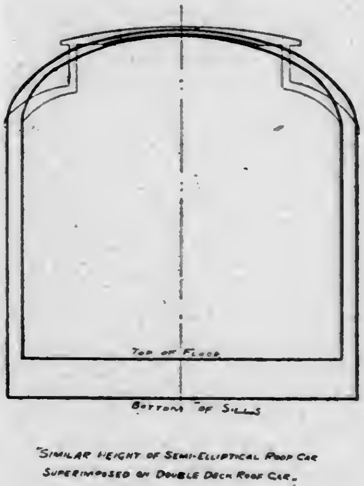


FIG. 4

entirely; and, in cases where cars turn over, the roof frequently collapses, the car frame is always racked to such an extent that it has to be rebuilt. The superiority of the semi-elliptical roof, with its unit post and carlines, and its reinforcing properties, seems to them self-apparent; and the liability of disrupting a structure of this kind is immensely decreased.

They argue further that the roof of a car, like the roof of a house, is a not particularly attractive feature of the structure from the outside. It has no bright colors, nor any lines that tend to make it attractive. While the semi-elliptical roof is a novelty, it may attract attention; the curves and lines of this roof are certainly as attractive as the ordinary double-deck roof, but this point of outside appearance seems insignificant.

These claims for greater safety of the semi-elliptical roof are denied by the other side as being only theoretical and far fetched and incapable of proof.

It is remembered by some members of the Association that

about twenty years ago a considerable number of coaches and sleeping cars were constructed with what is known as the "Mann" roof. Several of these cars were in wrecks, and where overturned there never was any marked superiority shown as to strength to resist punishment in the cars having these strongly constructed "Mann" semi-elliptical roofs. One important objection to the semi-elliptical form is that in order to meet clearance dimensions of many Eastern tunnels the inside clear height would have to be considerably reduced, with marked objections to such a contraction in inside height. (See Fig. 3, Plate J.)

APPEARANCE.

The friends of the semi-elliptical roof state that in the interior of passenger equipment, the tendency has been toward the elimination of straight lines and angles, and to gradually approach the semi-elliptical shape; that the upper deck of most of our cars has been rounded, making a segment of a circle. The semi-elliptical roof, having the appearance of a regular well-defined arch, is novel; but with its increased possibilities of decoration they believe the appearance of a semi-elliptical roof would seem to have many advantages over the double deck.

The opponents of semi-elliptical section consider, for general adoption in the East, at least, that the necessary reduction of height to suit clearance requirements of tunnels would materially detract from the roomy appearance of cars so designed, and they point to the photographs of interiors of such cars. They refer to the less roomy appearance of the large number of European cars, which have semi-elliptical roofs. They refer also to the considerable number of Mann roof cars built formerly for New England roads, which were found noisy and generally objectionable by patrons of the roads, so much so that the use of such designs was abandoned after a few years.

COST AND ECONOMY.

It is claimed by some that the first cost of the double-deck roof is necessarily greater than the semi-elliptical, and its maintenance the same. That with the double-deck roof, the expensive fitting of deck sash, the expensive repairs necessary to the fastenings, weather strippings, etc., replacement of lights, and the flashing of roof, unquestionably means more expensive cost of maintenance.

With the semi-elliptical roof, it is claimed that the continuous headlining from one side to the other, the continuous roof from one side to the other, on the outside, plain surfaces, the lack of corners to crack, the lack of crevices to hold dust, dirt and moisture, the complete protection from water and its consequential damaging effects, are all indicative of the low cost of maintenance.

The upper-deck advocates concede that there may be a slight difference in first cost and in maintenance, but that the advantages to the passenger more than compensates the railroad, and warrants it in expending the slight additional amount.

VENTILATION.

The claims for superiority in ventilation with the semi-elliptical roof are argued as follows:

The idea of the deck sash expelling the foul air from the interior of the car and at the same time providing an intake for fresh air—in other words, performing two purposes diametrically opposed to each other, is, on the face of it, illogical and unreasonable.

Deck-sash ventilation is entirely dependent for its movement upon the difference in temperatures of the fresh and foul air—in other words, upon the gravity system; and in a railway coach, moving from forty to sixty miles per hour, the air currents incident to the movement of the train through the air, and the consequential air pressures, are so great in their influence, as compared with this movement of air incident to the gravity force, that the latter is almost entirely overcome.

The impossibilities of regulating the temperatures of the ordinary passenger equipment to the satisfaction of the general public, is unquestionably partially the result, if not largely the result, of improper ventilation—insufficient supply of oxygen for the human lungs. Thus, this insufficient supply of fresh air produces physiological results upon the human system of respiration, and that, in turn, causes discomforts apparently from heat or cold. Some are too hot, while others are too cold. Experiments have shown that with a well ventilated car the temperature inside could be varied from 66 to 74 degrees without the slightest interference with the comfort of the passengers.

Furthermore, there are a great many thousand double-deck passenger cars in service, and there have been a great many experiments and a great many able men have devoted their energies to perfecting a ventilating system for this style of equipment, but without any practical success up to the present time.

The greatest success in the ventilating of the double-deck passenger equipment has been obtained by one large railroad system and one large private car builder, by the use of exhaust or suction ventilators in the roof, *with the deck sash tightly sealed;* thus, in obtaining improved ventilation, one of the first steps in the development is to tightly close and put out of use the deck sash.

The poor ventilation obtained from the gravity system, or from deck sash, being inadequate for the present requirements, a mechanical system of ventilation seems imperative. This, therefore, is obtained by the location of suction ventilators pulling out the foul air from the top of the car, and suitable intakes furnishing fresh supply of air at the floor line of the car.

The semi-elliptical roof, therefore, with the improved methods of ventilation, is just as effective—and it is claimed more so, than the ordinary double-deck roof.

The users and advocates of upper-deck roofs feel assured that no claim for advantages in ventilation can be claimed for the semi-elliptical roof and that this has been extensively proven by the large number of coaches and sleepers heretofore built with the long since abandoned "Mann" roof. They further point to the fact that European roads are rapidly adopting the American upper-deck roofs on account of the well-recognized superior ventilation possibilities. It is argued that any improved system of ventilation is equally effective and generally more easily applied on cars having upper decks.

The introduction of steel in place of wood, for passenger equipment, from present indications, is a foregone conclusion. Yet it seems reasonable—in fact, it almost seems imperative—that with the introduction of steel for building passenger equipment, the design of car should be so modified, and the frame so constructed as to utilize to the maximum extent all the structural properties of the steel material.

It is evident that the forms and designs adopted to utilize wood to the best advantage do not necessarily apply to metal. Therefore, it would seem not unwise that efforts should be exerted to develop a car of the maximum efficiency, independent of stereotyped forms of construction, developed by practice and usage in wooden cars.

The principal arguments for and against the present generally adopted form of upper-deck roofs on American railroad cars are so directly contradictory and at variance that your committee deems it difficult and unwise to attempt to draw conclusions and so content themselves with laying the arguments thus fully before the association, leaving it for time and public sentiment to bring about "the survival of the fittest."

BEST CONSTRUCTION OF FLOORING.

While a vast amount of experience has been gained in the use of various materials as floor coverings in buildings, etc., wood alone with some textural covering has been used to the greatest extent in passenger car work. Under the modern conditions of car design, the first consideration is the safety of the people carried. Thus it is that a metal or metal and composite construction should be used for floors, particularly in cars of steel design, to eliminate, as far as possible, injury done by wheels or parts of trucks or any outside substance punching through them in case of an accident.

A great many kinds of material have been suggested; still for safety there are good arguments for starting with a steel floor of some considerable thickness. Many of the designers and builders to-day are using nothing but a plain or special corrugated steel or iron sheet extending from side to side of car. This, of course, affords but very little protection from outside interference in case of wreck. To this corrugated steel floor a plastic floor is applied, mostly composed of sawdust and magnesia cement.

Coverings called under various trade names, such as Monolith, Karbolith, Asbestolith, Acondolith, Flexolith and other mortarlike combinations of asbestos and cement, have been used in combination with steel plates, wire netting and rolled shapes. The requirements for maximum insulative properties against sound and heat are probably met in most of these products equally well. These, however, are requirements that are most essential in passenger car work and too much stress cannot be laid upon them. It is expected that their surfaces should be impervious to hot or cold water, and be frequently flushed and cleaned without deterioration of the material constituting the floor.

The committee does not believe that it is within its province to recommend a standard floor construction, but suggests that the floor construction of a steel passenger car should embody elements to obtain the following results:

- Fireproof surfaces—outside and inside.
- Resistance against loose brake gear, wheels, etc.
- Resistance against transverse and diagonal strains.
- Resistance against breakage from vibration.
- Non-conductor of heat.
- Minimum of weight.
- Non-conductor of sound.
- Satisfactory walking and wearing surface.

RELATIVE MERITS OF VARIOUS MATERIALS FOR INSIDE FINISH FOR FIREPROOF CONSTRUCTION.

There is a great difference of opinion as to how far it is advisable to substitute metal and fireproof construction for wood, and whether it is advisable or actually necessary (at least on surface railroads) to go to the extreme, or in other words, to eliminate all wood.

Many designers feel that there can be little practical objection to the use of a limited amount of wood—as, for instance, for seat arms, sash mouldings and other interior finish—so long as the use of steel in the underframing and the elimination of a

large section of wood in the superstructure, which would be liable to fire, heat and splinter, is provided for. For it is believed that the window glass is just as dangerous, if not more so, to passengers when cars are wrecked as the kind of woodwork referred to above would be. It has been suggested that perhaps it would be a benefit in some cases—as, for instance, in tunnels where the windows are of very little benefit as far as light is concerned and practically nothing may be seen from the windows—that the glass would be made with interwoven metal screens.

The committee consider that, as a general proposition, the most desirable materials for inside finish for steel passenger cars should have the maximum advantages as to durability, non-inflammability, insulating qualities, non-hygroscopic qualities, lightness, neatness of appearance, reasonable initial cost.

It is conceded that the material which meets most of these requirements is light sheet steel. This material is not always feasible for use in all locations. Artificial board, aluminum, and in some cases fireproofed wood or other material, are often better suited for interior finish above the window sills and for the head lining. Aluminum has the advantage of lightness, but it is comparatively expensive. Interlocking sheet steel sheathing has been recommended for interior finish between floor and window sills. Brass and copper might be used with good effect, but to most railroads their price is prohibitive. For mouldings, finishing pieces, etc., very serviceable and adequate material may be procured in drawn steel and aluminum.

There are many kinds of artificial boards on the market, more or less fireproof and all hygroscopic with the exception, possibly, of Transite. Unfortunately, with most of these the fireproof qualities are in inverse ratio to the hygroscopic qualities. These artificial boards are made up from different bases of asbestos, wood pulp, etc., combined with cement and other ingredients. The artificial materials which have been mostly used are as follows: Transit, Durite, Fiberite, Uralite, Vitribestos, Indestructible Fiber, Composite Board, Service Board, Agasote (Impermeable Mill Board).

Fireproofed wood is not generally recommended for interior finish for the reason that the fireproofing chemicals are apt to exude, and spoil the finish and the process at present is not always permanent. To be properly fireproofed the weight of the wood should be materially increased by reason of the chemical treatment, and these chemicals also corrode any steel, wood screws, nails, etc., which come in contact with them.

One of the most important features for inside finish is insulation against heat and cold. Not only should an air space be provided between inside and outside finish, but any metallic substance used for inside finish should be backed up with some non-conductive material. Steel or aluminum plates backed up with Ceilinite, an asbestos cloth, have been tried.

The whole question of material for inside finish from a standpoint of insulation against heat and cold, has not been thoroughly worked out, and is a subject to which manufacturers should give prompt attention, looking toward the speedy production of a serviceable product that is permanently fireproofed.

CONCLUSION.

The entire subject of steel passenger car construction, as may be seen from the above report, is as yet largely in an experimental state, and it is quite difficult, if not impossible, to draw definite conclusions or give definite recommendations which would be suitable to all conditions. From the determined manner in which the construction of steel passenger cars has been taken up by so many railroads and manufacturing companies during the last few years, further interesting and valuable information will unquestionably be obtained in the very near future. It is to be hoped, however, that an effort will be made toward uniformity in construction and design in order that the most satisfactory results may be obtained.

Automatic Connectors.

Committee—G. C. Bishop, chairman; Henry Bartlett, F. M. Gilbert, J. M. Shackford, J. F. DeVoy.

In order to ascertain the present status of the automatic connector, the committee has written to all the manufacturers of automatic connectors that could be found in the United States, asking for full information with reference to their connectors and all points that they thought it desirable to cover.

In the types of connectors referred to in this report, a butting connector is understood to be one in which the contact faces are in a vertical plane at right angles to the track; the side-port connector is one in which the contact faces are in a vertical plane parallel to track.

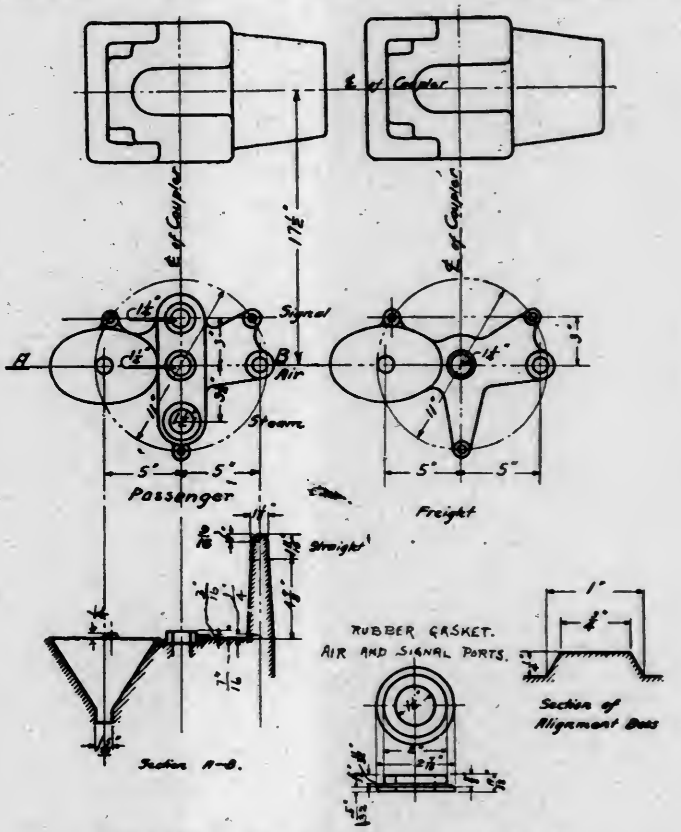
Four types were found which were perfected to a point that the committee felt they could consider them, one being of the side-port type and three of the butting type.

The collecting and registering devices are principally of two types: first, pin and funnel; and second, some form of wings or wing and tongue. Of the connectors referred to, the side-port connector had a wing and tongue collecting and registering device and two of the butting connectors different forms of wings and one a pin and funnel. The committee has considered all these carefully and is of the opinion that the pin and funnel, or some modification thereof, seems to offer the best possibilities.

From a careful study of these designs the committee recommends the butting type of connector. That the center line of the air-brake port should be 17½ inches below the center line of the coupler. For passenger car connectors the sequence of ports from the top to be as follows: air signal, air brake and steam heat, to be located on the vertical center line of the coupler. Air-signal and air-brake ports to be spaced 3 inch centers; the center of steam-heat port 3½ inches below center of air-brake port.

There are in a few instances four ports required between passenger cars. The connector is recommended so located that a fourth port can be added above the signal port.

The air-signal and air-brake gaskets to have an opening of 1¼ inches and to be interchangeable. The steam-heat gasket to have an opening 1½ inches in diameter. The registering device to follow the pin and funnel principle. The gathering range vertically to be not less than 2½ inches above and below the center, and horizontally to be not less than 3½ inches to the right and to the left of the center.



RECOMMENDED TYPE OF AUTOMATIC CONNECTORS.

The pin and funnel to be located on the horizontal center line of the air-brake port, the center of the pin to be located 5 inches from the center line of the connector on the right-hand side facing it; the center of the funnel 5 inches to the left of the center line. The pin to have a spherical end and to be 6 9-16 inches in length from face of connector, its outer end to be 1⅛ inches in diameter for at least 1 11-16 inches. The hole in the funnel to be 1 5-32 inches in diameter.

Three stops to be located on the face of the connector on a horizontal line 3 inches above the center of the air-brake port and on a circle of 5½ inches radius, whose center corresponds with that of the air-brake port; the bottom stop to be located on the center line of connector 5½ inches below the center line of the air-brake port.

For freight car connectors all but the air-brake port to be omitted, the relation between this port and the collecting and registering devices remaining the same.

While the committee has not referred the question of patents to any authority, it has been generally conceded by the manufacturers that there are no patents covering the contour recommended.

There must be flexible action between the train pipes and connector somewhat in excess of the total longitudinal movement of the coupler. Of course, it is desirable to get this flexibility, if possible, without the use of hose.

The committee, in order to give the manufacturers some basis to work on, has recommended dimensions and suggestions for a contour, but wishes to call attention to the fact that suggestions have not been developed from a service test, and therefore recommends that the association arrange for a thorough trial of connectors on these lines.

MASTER MECHANICS' ASSOCATION

FORTY-FIRST ANNUAL CONVENTION.

The convention was opened, June 22, at Atlantic City by the president, William McIntosh.

President's Address.—Mr. McIntosh's address, an abstract of which follows, was largely devoted to the most important problem before the mechanical department—that of organization.

Without question our greatest problem is that of the selection, treatment and organization of men. The recent years of abnormal business activity have brought to the surface the slumbering tendency of organized labor to drift away from harmonious relations with employers and array itself on the side of the radical and demagogue, who seek notoriety and selfish advancement in creating and fostering discord between employers and employees whose every interest are identical. We know that any attempt on the part of either to operate independently must result disastrously. * * * How can employees expect to be benefited by such complications? Their interests are so closely allied with the interests of the company they serve that they must be proportionately affected by reduced earnings.

The points of issue between railroad companies and their employees are usually few in number and easy of solution. Wages are at present generally satisfactory, and only questions of methods conflict. Mechanics, especially machinists, are reluctant to adopt other than hourly rates of pay, while manufacturers and corporations are in favor of some system of fixed output, profit sharing or piece-work. The men claim, and with some grounds for their contention, that they have frequently been treated unfairly where piece-work has been adopted. This was often owing to bad judgment on the part of local officials in their efforts to adjust piece-work prices that had been established at unreasonably high figures, as a result of the adoption of hurriedly prepared piece-work schedules, or perhaps no schedule at all, merely guessing at prices and then arbitrarily putting them in force. On the other hand, workmen have interfered with normal results by restricting the output, under the mistaken idea that they would benefit thereby. Abnormal rates are bound to result from such methods, and dissatisfaction and protests from the workmen follow, for no matter how fairly and carefully these adjustments are made, the workmen are naturally suspicious that some advantage is being taken of them. It is evident, therefore, that the establishment of piece-work prices should be arranged with the utmost care and deliberation. It must further be borne in mind that agreements to be enduring and stand the test of time should be agreeable to both parties interested, and that due consideration should be given the workmen's side of the question in order to insure this result. Fairly adjusted piece-work rates should prove advantageous to the workmen, enabling them to earn much better wages with but little greater physical effort, only requiring closer mental application and attention to details on their part, while the manufacturers and corporations would be the gainers by having their tools and machinery working at all times to their full capacity. The only one to suffer under the stipulated output system is the indifferent and lazy workman.

In my railroad experience, extending over forty years of active service in different departments and various branches of railroad work, much of the time in charge of large bodies of workmen, I cannot recall an instance where it has not been possible to adjust any of the ordinary differences that arise by free and frank discussion of the questions at issue with the men affected. I, therefore, think the average railroad employee is too intelligent to be led very far astray by scheming politicians or unwise agitators. They must keep in mind that their own and their families' interests are bound up with the company they serve, and that they cannot prosper when the company does not. * * * The folly of workmen assisting in directly or indirectly curtailing the earning capacity of the railroads, and at the same time expecting to continue to draw the liberal wages they were receiving when earnings were good, is about as ridiculous as the tailor to expect golden eggs after he had killed the goose that laid them.

My honored predecessor pleaded eloquently for a man. He said, "We have inherited. What shall we bequeath?" Yes, we want many men, both in command and in the ranks. Wise men, strong men in their respective lines, reasonable men and independent men, who would respect the rights of others as readily as they would contend for their own. We must have young men qualifying themselves for advancement, young men with patience and determination to work up, step by step, to the most important positions. It should not be necessary to seek beyond their ranks for selections to fill positions that become vacant. There should be a waiting list of men available. Each of us who now occupy official positions should have his own successor selected, so far as it is possible to prepare and qualify him by training for the position.

No doubt we do not know our men as well as we should, and while it may be impossible to gather this intimate knowledge directly, we can accomplish much by gathering indirect information and keeping systematic records. We perhaps are not training our young men as thoroughly as we should, and to accomplish this result we need the co-operation of managing officials. This will no doubt be forthcoming on proper presentation of feasible plans, as is evidenced by the hearty support given recent liberal methods of training apprentices, now being introduced on several railroads, and which promises to be much farther reaching in satisfactory results than its earlier promoters dared to hope for.

We require more than men. We need an organization. An organization that develops men; develops them broadly and quickly. We need men of all kinds—leaders and followers. The followers are most important, for if we develop the followers the leaders appear automatically, and consequently take care of themselves.

Let us note for a moment the careful training given young men in many lines of business to qualify them for important positions awaiting—and railroad work is not less important. One of the prominent trans-Atlantic lines has just commissioned a substantial ship for training purposes, and from which will be graduated recruits for the fleet, and in the line of recent experience by railroad companies of the difficulty of securing reliable help, perhaps the time is now propitious for them to take action of the kind suggested, adopting some such system of education, training and promotion that will first induce promising young men to take up employment, then educate and train them in the line of their duties, finally opening up to them a line of promotion that will encourage them to remain permanently in the service and eliminate the growing tendency that now exists of employees seeking other employment as soon as they have gathered an outline of the duties they are expected to perform. Certainly well prepared young men are worth as much to the railroads as they are to other industries to which they are attracted.

It seems fitting to sum up what the man who must assume our duties and responsibilities must be prepared to do. He must prepare himself for leadership by efficient service in subordinate places. He must know men. He must help in building up an organization of men. It is a mistake to always seek genius; it is more important to build up that combination of various abilities, capabilities and temperaments which will form a united, homogeneous body before which the difficulties of the greatest problems will crumble and disappear. We should all strive to build up a working organization which shall be so complete and so sat-

isfactory and with a correct policy so firmly established that those who follow can find little which they will be willing to change or to discard.

As president of this association I attended the recent conference of state governors which assembled last month at the White House, by invitation of the President, for a discussion of means for the conservation of the resources of the country. Before the Master Mechanics' and Master Car Builders' associations lies a great responsibility in that we represent an enormous consumption of natural resources. To be faithful to our trusts we must, therefore, use every effort to carry out the spirit which led to the recent conference.

"Conservation of Resources" was the object of the assemblage at Washington. This suggested to my mind the thought of conservation of energy as applied to the problem before the railroad officials of this country. I wish to suggest a thought which is not new, but is, in my judgment, becoming more important every day. Briefly stated, it is that sooner or later the energies of mechanical officers of railways must be conserved by the concentration of every effort. Sooner or later the Master Mechanics' and Master Car Builders' associations must be consolidated into one powerful, united, representative organization. Let me place this proposition squarely before you by expressing the opinion that the progress of the times, the conditions of our work and the character of our problems demand this step. I will not presume to outline how this should be brought about, but I most earnestly recommend that the executive committee be instructed to raise the question with the executive committee of the Master Car Builders' Association and consider ways and means looking toward such consolidation, which I believe, if we are true to the interests which we represent, must not be long deferred.

Secretary and Treasurer's Report.—There are 862 active members, 19 associate members and 37 honorary members, making a total of 918. There are four vacant scholarships at Stevens Institute. The treasurer's report showed a balance on hand of $1,912.77. John Medway, '88; W. H. Thomas, '83, and John Player, '81, were elected honorary members.

Mechanical Stokers.—Mr. Tonge emphasized the necessity for a mechanical conveyor from the tender to the stoker. Mr. Walsh spoke of the development and success of the Kincaid stoker on the C. & O., but stated that with the introduction of the wide fire-box engines the necessity for the stoker disappeared. The advantages due to the reduced cost of flue maintenance and a slight economy in coal were offset by the disadvantages in keeping the stokers in repair. It was very inconvenient to take care of the stokers at terminals and they were unpopular with the firemen. Mr. Seley spoke of the necessity of combining the intelligence of the fireman with the work of the stoker, in order to properly distribute the coal. Unless the stoker can be efficiently directed in this way there is liability of greater damage to the flues due to the admission of cold air through holes in the fire, than from the doors. Mr. Walsh stated that an underfed stoker was being experimented with on one of the roads.

H. T. Bentley stated that Crosby stokers had been in use on the C. & N. W. for about 18 months. They performed the work satisfactorily, but the need for them was not urgent because of the small engines on that road and the fact that very little difficulty was found in securing firemen. Mr. Rumney spoke of the Hayden stoker on the Erie and said that it showed an increased coal consumption, but that this might be due to the fact that on each of the eighteen test trips a different fireman, not familiar with the use of the stoker, had had charge of it. Arrangements have been made to supply coal which passes through a 3 in. screen and five more of these stokers have been ordered. Improvements have been made so that no hand firing will be necessary. Dr. Goss suggested that in order to get the best results it might be well to make some changes in the design of the boiler. If the stoker could be put in at a little lower level and a supplemental fire door be placed above it, the fireman could supplement the stoker in getting a proper distribution of the fuel. In his opinion the chain grate stoker, or any type which involves a long continued process, will hardly be suited for use on locomotives because of the rapid changes in the operation of the locomotive, making it essential that provision should be made for quickly changing the condition of the fire.

Mr. Gaines thought that the limit of a fireman's capacity had been reached on some of the larger engines, even with wide fireboxes, in hot weather. Mr. Devoy thought that the necessity for a stoker could be obviated by a proper fire-box design and called attention to the fact that the wide fire-boxes on the C. M. & St. P. are only 60 in. wide and deeper than ordinarily used. Mr. Deems thought that if there was an urgent demand for any one thing on the railroads of this country it was a successful stoker. Mr. Pomeroy cited the case of a locomotive tested on mountain grades on a Western road. The engine could maintain its maximum tractive power up to about ten miles an hour, but owing to the inability of the fireman to shovel more than 7,600 lbs. of coal per hour it could not realize a speed greater than 7½ miles per hour. If a stoker could be developed which would handle one-third more coal than the fireman it would certainly be well worth the effort. Mr. Vaughan favored the idea of a stoker that would deliver a certain proportion of the coal, to be supplemented by hand firing. The committee was continued for another year.

Blanks for Reporting Work on Engines.—The discussion of this subject indicated that the best forms to use would depend largely upon local conditions. Messrs. Gaines and Wildin emphasized the necessity of having daily reports showing the condition of the locomotives.

Proper Width of Track on Curves.—The committee on "the proper width of track on curves to secure the best results with engines of different lengths of rigid wheel base" was continued to represent the Association on a joint committee with the members of the Maintenance of Way Association and Master Car Builders' Association.

Smoke Prevention and Fuel Economy.—In opening the subject of smoke prevention Mr. Bentley stated in part:

"Having a large number of locomotives working in and around the city of Chicago, where the smoke inspection bureau has a staff of very active inspectors always on the lookout for violators of the smoke ordinance, we have tried nearly every scheme that has been suggested, or that we could think of, having a man specially qualified to watch results.

"When reporting on any particular device we have invariably been told that, 'It is a good thing if engine is properly fired,' which brings us back to the personal equation; it has been our experience that no device we could put on an engine would do much good if engine was improperly fired.

"We do not believe that it is possible to entirely eliminate all of the smoke at all times from a locomotive burning bituminous coal, on account of the nature of the service; first working at full stroke, then at short cut-off, and suddenly being shut off entirely on account of being stopped by a signal, just as enough coal has been put in fire-box to take the train up a grade or out of the way of a quickly following train, but we do say, that by careful firing, more than anything else, and a close working understanding between engineer and fireman, the amount of smoke emitted need not be of such an amount as to be open to serious criticism.

"We have used so-called smokeless coal with fairly good results, but it is not entirely free from smoke, and has given us trouble in other directions. Have also tried coke, which is free from black smoke, but the fumes emitted are very objectionable.

"In concluding we believe the smoke nuisance can be reduced to a minimum by the following: Co-operation on part of engine crew, careful firing, the use of a brick arch, coal properly broken up, engine and grate area of sufficient capacity to do the work required without crowding, grate openings large enough to supply the proper amount of air."

W. C. Squire then read a paper on fuel economy, in which he considered certain recent improvements in American and European practice for improved combustion and smoke prevention. In the discussion which followed the thought was expressed several times that while mechanical devices might do much to aid smoke prevention, yet the engineers and fireman are

a very great factor in the problem and results cannot be obtained without their assistance and hearty co-operation. Mr. Manchester spoke of the necessity of giving the smoke inspectors considerable authority over the enginemen. Mr. Gaines called attention to experiments which had been made in stationary practice, which indicate that to burn soft coal without smoke the gases must be kept at a high temperature until they are consumed. Mr. Setchel suggested that the use of a mechanical stoker might reduce the smoke nuisance, but Mr. Curtis was of the opinion that the conditions of locomotive operation were such that the mechanical stoker would not entirely remedy the difficulty.

Washing Out and Refilling Boilers.—After reading the report Mr. Bentley said: "Since writing this paper I have had opportunities of seeing in operation hot water wash-out plants that actually do in a very satisfactory manner all that the most sanguine would expect. At one place I found the steam and hot water being utilized to heat two tanks, one to a temperature of 140 degrees F. for washing out and the other at from 175 to 200 degrees for filling up, and there appeared to be plenty of hot water at these temperatures to meet all the requirements.

"In figuring on the actual saving in time, coal and water, the amounts given by your committee are probably under instead of above the mark and we would revise these figures as follows: Labor, 30 cents; water at 7 cents per 1,000 cubic feet, 14 cents; coal at $2.00 per ton, $1.00; total per engine, $1.44. Just at present, owing to the business depression, we are not crowded for power, but in busy times anything that will enable us to turn an engine out in one-half the time, after being washed, is worth considering.

"One thing that impressed me in connection with the filling up of boilers was the large sized pumps used, which made it possible to fill a large locomotive boiler in nine minutes, where the best we now do is about 20 minutes. A larger blow-off pipe than 1½ inch, as used on most roads, is very necessary for quickly emptying and filling boilers. The reduced amount of boiler work necessary is evidenced by the number of men laid off since the introduction of hot water washing out, at several places investigated.

"The men handling the hose can do so without inconvenience, where the temperature does not exceed 140 degrees F., but in filling up, where the water is as hot as 200 degrees, it is not necessary to handle the hose, and therefore no trouble is experienced. The savings from coal, water and labor alone will pay a handsome interest on the cost of installation and we have no hesitation in recommending this system, where economical results are desired."

Mr. Redding, speaking of the Raymer system, mentioned the great advantage of being able to get an engine out quickly, for, even though on some roads it may not be necessary to wash the boilers very often, it is often necessary to empty the boiler for other purposes. Mr. Vaughan spoke of the boiler washing plants on the Canadian Pacific; in some instances they are connected so as to be used with the feed water heaters for the roundhouse boilers, making an economical arrangement. In addition to the advantage of washing out with warm water it is often desirable to blow down a boiler and fill it up quickly and the washing out system fills this purpose admirably.

From the discussion, it would appear that the best practice is to remove the top wash-out plugs, gradually injecting cold water until the temperature has been brought down to about that of the washing out water. The general practice seems to be to blow out the boiler and then wash it with water at about 140 degs. F. As the sheets are at a temperature much higher than this there is a question as to whether the plates are damaged by local contraction. Mr. Curtis said that the practice on the L. & N. was to cool the water in the boiler by injecting cold water and to commence washing out at about the time the water recedes to the top of the crown sheet. In that way the mud can be easily removed, but if the water is allowed to recede while the boiler plates are at a high temperature it will be baked on the plates and be very difficult to remove. Mr. Sanderson was of the same opinion.

High Speed Steel.—The topical discussion on this subject was opened by J. A. Carney, who spoke of the great improvement in machine tool design which had resulted from the introduction of the high speed or alloy steels. Not only is it possible to take heavier cuts at three or four times the speed possible with carbon steels, but the alloy steel continues to work almost indefinitely without losing its cutting edge, thus saving a large percentage of time formerly taken for removing, regrinding and replacing tools. The cost of dressing the tools is greatly reduced and a much smaller number of tools are required to be carried. Mr. Carney mentioned a number of specific instances where great improvement had resulted from the introduction of high speed steel in various forms, and summed up the results brought about by the introduction of these steels as follows:

Heavier cuts at faster speeds.

Heavier and more powerful machine tools.

Improved methods of fastening the work.

Use of inserted tooth cutters in place of single tools.

It is difficult to say how much a reduction in the cost of machine work can be attributed to alloy steel, but this fact is apparent, an increase in machinists' wages of about 35 per cent. in the past six or seven years has not increased the cost of machine work and in many cases the cost has been lessened by the use of alloy steel and the machines designed for its use.

Mr. Gaines spoke of the splendid results which had been obtained from high speed steel with vanadium content in connection with pneumatic tools for caulking, chipping, etc. Mr. Vaughan spoke of the necessity of caution in the use of high speed steel tools to prevent the unnecessary breakage of the lighter machines. In selecting high speed steel it should be tested for strength, as some of the steels are more brittle than others. The variety of these steels in use in a shop should be reduced to the least possible number, as more effective results can be obtained than when it is necessary to handle a number of different kinds through the tempering room. Results show that a drill will pass through about 1,000 ft. of metal per inch of wear.

C. D. Young mentioned remarkable results which had been obtained from vanadium high speed steel.

Mr. Sanderson mentioned the necessity for careful study on the part of the shop management in order to force the output of each machine to the full capacity of both the machine and the tool steel.

Mr. De Voy thought it might be well to give less attention to turning the steel off driving wheel tires with such heavy cuts, at such a high speed, and give more attention to leaving a witness mark on each set of drivers, thus preventing waste of material. He was also of the opinion that removing such heavy cuts injured the material and was responsible for breakage of the driving wheel flanges. George L. Fowler cited a case where a street railway company reduced the trouble from cracked wheels and chipping of flanges by taking lighter finishing cuts.

Mr. Bentley thought it advisable to leave the wheel tread smoother than has been the general practice; however, he did not feel that taking heavy cuts was responsible for flange failures. Mr. Curtis suggested that climatic conditions were largely responsible for driving wheel flange failures and this seemed to be the opinion of several of the other members. Mr. Vaughan suggested that tire troubles were also due to a lack of stiffness in the wheel center. Messrs. McIntosh and Redding suggested that improper shimming might also be responsible for it.

Castle Nuts.—Mr. Bentley suggested that on the larger nuts, with standard threads, a second hole should be placed in the bolt to get a finer adjustment. A motion was carried to the effect that the Association recommend the dimensions shown in the report for use by its members during the coming year, with a view of adopting them as standard, if found satisfactory. The committee was continued for another year to follow the developments and to get in touch with the manufacturers and others with a view of making the dimensions standard at the end of the year.

The Apprenticeship System.—Mr. Tonge opposed having classes in the evening, after the boys are tired out with their day's work. H. T. Bentley said that on the C. & N. W. they had

..o apprentice instructors for 45 apprentices. The apprentices ..rmed a club and during the past year held fourteen meetings .which papers on various topics were presented and discussed.

Mr. Thomas said that at the Topeka shops of the Santa Fe ..here were 163 apprentices. The instruction of these apprentices cost the company about 23 cents per day each. The average rate of pay for apprentices is about $1.35 a day, bringing the cost of wages and instruction to about $1.60 per day. The average apprentice does about 80 per cent. as much work as the average journeyman. As a result of the apprentice system a higher class of boys are entering the service and are not only doing more work, but a higher grade of work, than under former methods.

Mr. Manning stated that on the D. & H. they had an apprentice instructor for mathematics and drawing and two demonstrators in the shop. Splendid results are being obtained. Mr. Manchester advocated giving the apprentices roundhouse training. Mr. Quereau strongly advocated having some one whose entire duty was to look after the apprentices, as it is only in this way that the best results can be obtained. Mr. Vauclain said that for the past seven years the apprentices of the Baldwin Locomotive Works had been in charge of a superintendent of apprentices and that the result was that they do not have to go outside to hire skilled men, but have more than they can make use of, and these men are eagerly sought for by other concerns. The Baldwin Locomotive Works has three grades of apprentices, those with a common school education, those from the high or preparatory schools and those from technical institutions. Mr. Basford emphasized the fact that the committee does not intend, in its recommendations, that the shop instructor should teach in detail all the trades represented in the shop, but that it is his business to see that the trades are properly taught. Upon motion by Mr. Vaughan the principles recommended by the committee were adopted as recommended practice and substituted for the code of apprenticeship rules adopted in 1898.

Co-operation of the American Railway Association.—The following resolution was adopted: "Whereas, A sub-committee of the American Railway Association has made certain recommendations looking to the co-ordination of the work of the voluntary railway associations with that of its own, be it

"Resolved: That the president of this Association be empowered to appoint a committee from its officers to confer with the American Railway Association when requested." On motion this resolution was adopted.

Superheating.—After reading the report Mr. Vaughan stated that he wished to modify the figures in Table No. 3, in which the G2 engine superheaters are shown to have burned 66 and 64 per cent. of the coal used by simple engines. It had been found that the simple engines were as a rule used on lighter and faster trains than the superheaters and a good deal of the saving was possibly due to that fact. This does not affect the rest of the table. He also stated that eight or nine months ago he was a little in doubt on the superheater question, as there had been a number of failures. During the last six months this had been overcome by systematic attention in the roundhouse and by periodic tests of the superheaters, and since the end of March there had not been a single superheater failure out of 200 engines thus equipped.

Mr. Muhlfeld suggested that the committee be continued to investigate the degree of superheat which would give the most economical results, and also as to whether it is advisable to use the products of combustion, or the waste gases, or a combination of the two, to produce superheat. In reply to this Mr. Vaughan called attention to the paper presented at the 1905 convention, in which proof was submitted that a high degree of superheat was desirable and that, although useless heat was rejected, it was more economical to reject that heat than to be without it.

Mr. Vauclain said that he had always felt that highly superheated steam was not what was wanted in this country, it being only desirable to have sufficient superheat to overcome all the loss of the single expansion locomotive and at the same time to make it possible to use a normal boiler pressure of 160 lbs. This would overcome the need for a compound locomotive or for any special appliances or special metal in connection with the use of highly superheated steam. It would also make it possible to produce a locomotive which would require even less attention than a single expansion locomotive. He called special attention to the service results which had been gained by engines with a low degree of superheat on the Santa Fe. Mr. Vauclain made it very plain, both at this time and in connection with the discussion of other reports, that he considered a simple engine equipped with a superhater, which would give a low degree of superheat, as the coming engine. Mr. Foster (L. S. & M. S.) spoke of the satisfactory service results which were being obtained from two superheater engines on the L. S. & M. S. The committee was continued and asked to report on the degree of superheat which will give the most economical results.

Mallet Compounds.—Mr. Vauclain advocated the use of front and back trucks on Mallet engines in order to be able to give additional boiler capacity. He also stated that it had been definitely demonstrated that Mallet engines are not so well adapted to mountain pusher service as to low grade service, although they are highly economical in mountain service. Mr. Mellin (American Locomotive Co.) is of the opinion that front and back trucks should not be used with this type of engine. The trucks elongate the leverages and the front truck is a great objection when the engine is backing.

Briquetted Coal.—Mr. Nelson called attention to the fact that with gas coals a maximum of 18 lbs. of water could be evaporated per square foot of heating surface and that in road service this figure is about 12 lbs. The evaporation of 19 lbs. with the use of briquettes is remarkable. Mr. Rosing stated that with the use of briquettes smoke was reduced 50 per cent. as compared with lump coal of the same grade and the throwing of cinders is reduced in about the same ratio. Several tons of briquetted coal which had been piled in the open air for three years showed scarcely any change.

Size and Capacity of Safety Valves.—Mr. Nelson said that the safety valves used on the boilers in the St. Louis tests had been calibrated; the record of the names of these valves had not been kept, but the average amount of water passed per second for all of the valves tested was 1.29 lbs. In a recent test to see what would be the condition of a locomotive running at about the capacity of the boiler, when suddenly shut off, it was found that the 4 in. safety valve, which was being used, passed 2.4 lbs. of water per second. The recommendations made in the minority report were adopted.

Balanced Compounds.—Mr. Vauclain in commenting on the report called attention to the fact that the percentages of economy per indicated horse power ranged from 38 to as high as 54.10. Mr. Clark said that the balanced compound engines in use on the C. B. & Q. were giving satisfactory results. The engines probably require a little more time in the roundhouse than the simple engines do, but they make good mileage with very few road failures. These engines do not disturb the track nearly as much as do the unbalanced engines. Mr. Vauclain said that although the compound engine was capable of hauling greater trains at higher speeds than single expansion locomotives, yet he was of the opinion that superheater engines possessed that faculty to about the same if not a greater extent than the compounds.

Topical Discussions.—Several of the topical discussions were omitted because of lack of time and the members who were to introduce these topics were requested to send their remarks to the secretary for publication in the proceedings. This is also to be done in connection with the individual paper on "The Training of Technical Men" by Prof. A. W. Smith, which was not received in time.

Revision of Standards.—The committee made a number of slight changes in the wording of the text of the standards and suggested that certain additional information be added to some of the tables of information; also that certain sections be changed to agree with M. C. B. standards. It was also recommended that the shrinkage of tires should be on a uniform proproportionate basis. These changes will be referred to letter ballot.

Officers.—The following officers were elected for the ensuing year: President, H. H. Vaughan, assistant to vice-president, Canadian Pacific.

First vice-president, G. W. Wildin, mechanical superintendent, New York, New Haven & Hartford.

Second vice-president, C. E. Fuller, assistant superintendent motive power and machinery, Union Pacific.

Third vice-president, J. E. Muhlfeld, general superintendent motive power and machinery, Baltimore & Ohio.

Treasurer, Angus Sinclair.

Executive members: H. T. Bentley, Chicago & Northwestern; T. Rumney, Erie; T. H. Curtis, Louisville & Nashville.

ABSTRACTS OF REPORTS AND INDIVIDUAL PAPERS.

Blanks for Reporting Work on Engines Undergoing Repairs.

Committee—Theo H. Curtis, E. W. Pratt, C. H. Quereau, F. W. Lane.

The committee on this subject, which reported at the last convention, was continued for the purpose of submitting additional reports showing the condition of locomotives in service in addition to those undergoing repairs.

It is believed that Form "Exhibit G" covers in concise form the additional information desired. This report should be made monthly by the division master mechanics to the superintendent of motive power.

The daily reports referred to in the discussion of this subject at the last convention would be of service to division officials, but we believe that such a system cannot be successfully handled by the general officers of a large railroad and that on railroad systems owning 500 locomotives, or more, a monthly report of the conditions from the division officials is preferable to a daily report.

[For report to 1907 convention, including blanks, see AMERICAN ENGINEER, August, 1907, page 323.]

A, B AND C RAILROAD COMPANY.

STATEMENT OF CONDITION OF LOCOMOTIVES .... DIVISION .... 190 ......

F=Fair. B=Bad. X=10 Months' Service or More.

Engine.	Boiler			Machinery						Available Months Service Before Shopping	Last Repaired		Class of Repair necessary for Engines to be Shopped within three Months	Remarks
	Months service			Months service				Tires						
	Fire Box	Flues	General	Cylinders	Frames	General	Tires	Wear in 32nds	Present Thickness Inches		Date	Class		
11	X	1	1	X	X	1	1	7	$2\frac{11}{32}$	1	2-07	13	20	
38	X	5	5	X	X	5	5	7	$1\frac{11}{32}$	5	3-07	6		
39	5F	8	8	X	X	8	8	1	2	8	1-08	4		
41	X	1	1	X	X	1	1	7	$2\frac{11}{32}$	1	4-07	19	20	
IN SHOPS														
441	X	9	9	X	X	9	9	0	3	9	5-06	12	18	
780	X	X	X	X	X	X	X	0	3	X	3-07	17	24	
1204	X	X	X	X	X	X	X	0	3	X	3-07	14	25	
OUT OF SERVICE														
318	1F	1	1	X	X	1	1	8	2	1	9-06	12	12	
778	X	1	1	X	X	1	1	6	1	1	4-07	35	24	

RECAPITULATION

	In Service	In Shop	Out of Service	Total	Required Shopping In 3 Months
No. of Engines	22	3	2	27	9
Percentage	81.5%	11%	7.5%	100%	33.33%

EXHIBIT "G."

Mechanical Stokers.

Committee—Wm. Garstang (chairman), D. F. Crawford, J. F. Walsh, L. R. Johnson, George S. Hodgins.

The mechanical stokers used on locomotives in this country up to the present time have at least demonstrated the fact that freight and passenger engines, in road service, can be successfully fired by mechanical means. Mechanical stoking, however, has not made much progress abroad. In reply to an inquiry on this subject, Mr. G. J. Churchward, chief superintendent of the locomotive, carriage and wagon department of the Great Western Railway of England, says: "We have tried some mechanical stokers, but with our lump coal and the amount per mile we use, neither of the appliances I have yet seen has any prospect of superseding hand firing. Our average consumption per engine mile over the whole railway is only about 40 pounds."

The committee is advised that some experiments are now being made with an underfeed type of locomotive stoker, and other forms are also undergoing experiments on various railroads throughout the country. In presenting this progress report, the committee, while acknowledging its indebtedness to those who have kindly communicated the results of stoker trials, yet feels that the data so far available has not been sufficiently conclusive to warrant its being formally presented to the Association.

Stokers concerning which the committee have been able to obtain some information since the 1907 convention are the Victor (formerly the Day-Kincaid), the Crosby, Hayden and the Strouse types. It may be observed that the Day-Kincaid stoker originated on the Chesapeake & Ohio Railroad and the earliest experiments with this device were made on that road. (The above mentioned stokers are described in detail, but this part of the report is not reproduced since they were considered at length on page 147 of the April, 1908, issue of this journal.)

Apprenticeship.

Committee—C. W. Cross (chairman), B. P. Flory, G. M. Basford, A. W. Gibbs, John Tonge, W. D. Robb, F. W. Thomas.

The committee, recognizing the fact that there is a wide difference in organization and local conditions as to available material and facilities for instruction, considers that a hard-and-fast general apprenticeship code is impracticable, and, therefore, suggests the discarding of the code adopted in 1898 and the substitution of basic principles rather than a formal code.

To assure the success of the apprenticeship system, the following principles seem to be vital, whether the organization is large or small:

First: To develop from the ranks in the shortest possible time, carefully selected young men for the purpose of supplying leading workmen for future needs, with the expectation that those capable of advancement will reveal their ability and take the places in the organization for which they are qualified.

Second: A competent person must be given the responsibility of the apprenticeship scheme. He must be given adequate authority, and he must have sufficient attention from the head of the department. He should conduct thorough shop training of the apprentices, and, in close connection therewith, should develop a scheme of mental training, having necessary assistance in both. The mental training should be compulsory and conducted during working hours,* at the expense of the company.

Third: Apprentices should be accepted after careful examination by the apprentice instructor.

Fourth: There should be a probationary period before apprentices are finally accepted; this period to apply to the apprentice term if the candidate is accepted. The scheme should provide for those candidates for apprenticeship who may be better prepared as to education and experience than is expected of the usual candidate.

Fifth: Suitable records should be kept of the work and standing of apprentices.

Sixth: Certificates or diplomas should be awarded to those

* This report is unanimous, except that in principle No. 2 Mr. Robb favors evening classes at the expense of the company instead of day classes.

successfully completing the apprentice course. The entire scheme should be planned and administered to give these diplomas the highest possible value.

Seventh: Rewards in the form of additional education, both manual and mental, should be given apprentices of the highest standing.

Eighth: It is of the greatest importance that those in charge of apprentices should be most carefully selected. They have the responsibility of preparing the men on whom the roads are to rely in the future. They must be men possessing the necessary ability, coupled with appreciation of their responsibilities.

Ninth: Interest in the scheme must begin at the top, and it must be enthusiastically supported by the management.

Tenth: Apprenticeship should be considered as a recruiting system, and greatest care should be taken to retain graduated apprentices in the service of the company.

Eleventh: The organization should be such as graduated apprentices can afford to enter for their life-work.

For the purpose of obtaining data as to the conditions on various roads of the country, information was secured which is summarized as follows:

A shop plant for the purpose of this report is one in which general repairs of locomotives or cars are made. Fifty-five roads report 301 shop plants having apprentices and 67 plants in which there are no apprentices.

Fifty-five roads report a total of 7,053 apprentices in shop plants, distributed as follows:

Machinists	4814	Molder	82
Boilermakers	952	Electrician	14
Blacksmiths	311	Painter	137
Patternmaker	64	Upholsterer	27
Cabinetmaker	22	Carpenter	249
Tinner-pipefitter	365		

Reports from these roads show the average ratio of apprentices to mechanics in each trade to be as follows:

Machinists	1 to 4.8	Molder	1 to 8.2
Boilermakers	1 to 6.8	Electrician	1 to 8.6
Blacksmith	1 to 13.9	Painter	1 to 19.2
Patternmaker	1 to 3.3	Upholsterer	1 to 11.3
Cabinetmaker	1 to 23.3	Carpenter	1 to 72.4
Tinner-pipefitter	1 to 5.1		

The majority of replies indicate difficulty in securing apprentices in some of the trades, but no difficulty in others. A few replies state no difficulty in securing apprentices. This is apparently due to local conditions.

Of a total of fifty-five replies, ten, or 18.2 per cent., indicate that special instruction in trades is given apprentices. Forty-five replies, or 81.8 per cent., do not provide for special instruction.

Of a total of fifty-five replies, sixteen, or 29 per cent., indicate an established school system and thirty-nine, or 70.9 per cent., have no school system.

Of a total of fifty-five replies, thirty-nine, or 70.9 per cent., have apprentices and no school system, and eight roads state that they intend to establish such a system.

Eighteen replies favor day schools and three, or 14.3 per cent., favor night schools out of a total of twenty-one replies.

Fifteen replies show thirty-seven schools with 1,567 apprentices attending. The majority of the schools were recently established. Of these schools, twenty-eight are held in working hours and nine are held in the evening.

Of the above schools, thirty-four are compulsory and three are optional.

Of the fifty-five roads, twelve pay the apprentices for time spent in school.

Modern apprenticeship training has been introduced in seventeen shops on four roads with 506 apprentices since the convention of June, 1907. The following roads and systems of roads have made substantial progress in this work.

			No. Apprs.	Estab.
Union Pacific	1 school.	Omaha	71	9-1-06
	1 school.	Cheyenne	21	12-1-07
Michigan Central	1 school.	St. Thomas	36	12-1-07
Santa Fe	10 schools.		363	1908
Southern Railway	1 school.	Knoxville, Tenn.	...	1907
	1 school.	Spencer, N. C.	...	1907
Delaware & Hudson	3 schools.	Green Isle, Oneonta, Carbondale	86	1907

Substantial progress has also been made on roads having schools previously established, on the Grand Trunk Ry., Central R. R. of N. J., Boston & Maine R. R., Union Pacific R. R., Minneapolis, St. Paul & Sault Ste. Marie R. R. and New York Central Lines.

The Canadian Pacific R. R. and the Erie R. R. advise that they intend to install the improved plan of apprenticeship during the present year. Other important roads have the subject under contemplation.

The committee recommends that the Association provide an appropriation for establishing an exhibit of apprentice training to be a feature of each convention.

It has often been said that apprenticeship is a thing of the past. This certainly is not true of American railroads to-day, where a new apprenticeship has sprung up and has attained a healthy growth with brightest promise for the future. The committee does not hesitate to characterize the new apprenticeship as the most important influence introduced into railroad organizations during the present generation. This development is sure to be rapid, requiring great wisdom, combined with conscientious and systematic efforts in its control. We believe this movement will become the most powerful influence in supplying and preparing the men of the future for the motive power departments (and perhaps other departments) of American railroads; because the movement trains men in the ideal way, and because men properly prepared for their work constitute our greatest problem to-day.

An appendix to the report, prepared by W. B. Russell, gives a summary of the recent progress of apprentice training in England.

Best System of Washing Out and Refilling Locomotive Boilers.

Committee—H. T. Bentley (chairman), L. H. Turner, S. K. Dickerson, M. E. Wells, H. E. Passmore.

The best system of washing out is one that will do the work properly, with the least change in temperature in boiler, at a minimum expenditure of heat, and in the shortest possible time.

The fact that good results are obtained by having less trouble from fire-box and flue leakage, and a reduction in the number of stay-bolt breakages, and last, but not least, the reduction in terminal delays, would appear to warrant the expense of installation. The more nearly uniform the temperature is kept, the less expansion and contraction takes place, especially in the fire-box, which must reduce the vibration in stay-bolts and give them a correspondingly increased life. It has been demonstrated beyond a doubt that when a boiler is kept at a uniform temperature, the least trouble is experienced in the matter of leaking flues and fire-boxes.

In taking the question up with a number of superintendents of motive power, who are using various devices having the object of washing out, changing water and raising steam quickly, by the use of hot water, and live steam where necessary, the following information was gathered:

There are four or five different systems which have been in use from one to three years.

They cost from \$5,500 to \$20,000, depending on size and number of stalls equipped, which at 5 per cent. interest would mean an expense of from \$275 to \$1,000 per year.

The various systems reported are said to be entirely satisfactory; then can wash out and get ready for service twenty to twenty-six engines per twenty-four hours; the average time required to wash out and get an engine ready for service is from 55⅓ minutes to 4 hours 15 minutes; the average time formerly taken was 3 to 6 hours.

In all cases a very marked reduction was reported in flue leakages and broken stay-bolts, although very little exact data were available on this subject. At one point it has been possible to reduce the number of boiler-makers employed from ten to four, due to decreased boiler work since the hot water washing-out system has been installed.

Some of the other benefits derived are given as follows: No evidence of steam in roundhouse; always plenty of water at 212 degrees to refill boilers; temperature of water reduces time and fuel necessary to get engine hot; facility in turning engines; reduction of engine failures, reducing overtime; reduction of time at terminals where washing out is necessary.

Probably the most important saving effected by the hot water changing or wash-out system, is the rapidity with which the work can be done; engines are ready for service from one to two hours quicker than could possibly be the case with a cold-water system, which necessitates cooling an engine down after the steam has been blown off, before the engine can be washed out, and then directly after bringing the water back to the high temperature; such waste of heat, which means coal, would not be tolerated under any other conditions, but takes place daily at hundreds of roundhouses in this country, without any protest.

A simple arrangement used on one of the Western roads with very great success, for utilizing steam and water otherwise wasted, is to have wells into which cold water flows from the main, or source of supply, and to heat it by steam and hot water from engines; from this place the water is pumped for washing out and filling boilers. This is probably the cheapest system for furnishing hot water, but has the objection that the water has been blown from dirty boilers; however, as only a boilerful is taken, it is soon diluted and rendered innocuous by the fresh water injected into it from the tank.

The following actual savings have been reported:

Decreased cost of washing boilers. In 1906 with cold water, for labor alone it cost \$1.32 per boiler, whereas, with hot water in 1907, \$1.01 was charged against this item, or on the road reporting it, a saving of \$2,019.95 per year for labor alone, in washing boilers, was effected on an outlay of \$6,000.

Decreased cost of water used. This item may not appear at first sight to amount to much, but where a saving of 7,000 gallons for each boiler washed out can be effected, as has been reported,

this, at 7 cents per thousand gallons, in Chicago, amounts to 49 cents per boiler washed. It is the opinion of the committee, however, that this estimate of the amount of water saved is high.

Decreased amount of coal used. On one road this is given at 140 pounds per engine, which is probably low; this at $2 per ton would amount to 14 cents, so that with the three items mentioned we get a saving per engine of:

Labor	$0.31
Water	.49
Coal	.14
Total	$0.94

The saving of time at the roundhouse is probably, in busy seasons, more of an object than anything else mentioned, and as this amounts to cutting the time in half for washing out, it means, assuming that engine is not held for any other work, that with 1,000 engines, each turned two hours quicker than was possible with the cold-water system, you have a saving of 2,000 engine hours, and as engines generally have to be washed out once a week, or four times a month, in bad-water territory, it amounts to 8,000 engine hours a month, or 96,000 engine hours a year; this, if the engines have to be rented at $10 a day, which is a low figure for a large engine, in busy seasons, would cost $40,000; or, putting it another way, working 365 days of 12 hours each, it would require practically 22 additional engines to equal the 96,000 engine hours a year, which, at $15,000 per engine, would mean an expenditure of $330,000.

In conclusion, the committee recommends that boilers be washed out and filled with hot water; the savings obtained by doing so will pay a good interest on the necessary investment.

Superheating.

Committee—H. H. Vaughan (chairman), L. G. Parish, R. D. Hawkins.

During 1907 comparatively few engines were equipped with superheaters in the United States, although the Canadian Pacific Ry. continued to apply them to all road engines it constructed, 173 in all, bringing the total number of superheater engines on that road to 350, of which 110 are consolidation freight, 192 ten-wheel freight and 48 passenger engines.

The most important development in the United States has been with the "Baldwin" or "Vauclain" superheater, 52 engines having been constructed during the year 1907 equipped with this device. With this exception the only other engines constructed during the year with superheaters were two on the Union Pacific Railway, one of which was equipped with the "Vaughan-Horsey" smoke-tube superheater, the other with the "Union Pacific" smoke-box type.

A statement of the engines equipped during the year, so far as ascertained, is as follows:

Road.	Type of Superheater.	No. of Engines.
C. R. I. & P. Railway	Vauclain	1
P. S. & Northern	"	1
Central Railway, Brazil	"	2
Chicago & Alton	"	1
A. T. & Santa Fe	"	49
Central of Georgia	"	1
Union Pacific	Vaughan-Horsey	1
Union Pacific	Union Pacific	1
Canadian Pacific	Vaughan-Horsey	173

The "Vauclain" superheater may now be said to have developed beyond the experimental stage. It is of the smoke-box type, in which the waste heat of the front end gases is utilized to superheat the steam on its way to the cylinders.

It consists of two cast-steel headers* in the upper and two in the lower portion of the smoke-box, the upper headers having a passage extending from the T-pipe flange at the back of the header to a cavity in the front of the header, which is divided into three chambers by longitudinal and transverse ribs. The lower header is U-shaped in section, divided into three chambers by transverse ribs, the steam-pipe flange opening into the back chambers.

The headers are each open on the face, which is closed by a flange plate jointed to the header by bolts. Tubes 1¼ inches in diameter, No. 13 B. W. G. thick, are expanded into the flange plates.

The steam passes from the dry pipe to the upper chambers at the front of the upper headers, thence through the tubes to the front chamber of the lower headers and back through other tubes to the lower chamber of the upper header, thence to the middle chamber of the lower header, back to the upper header and thence to the rear chamber in the lower header, from which the steam connection leads to the cylinders. A steel plate partition within the tubes causes the gases issuing from the flue sheet to traverse the superheater tubes on their way to the stack, in order to obtain as much benefit as possible from the heat they contain.

This arrangement is evidently somewhat similar to the "Schmidt" smoke-box superheater, with the exception that the large flue leading from the fire-box to the front end, which in Schmidt's design enabled a high degree of superheat to be obtained, has been omitted, and consequently the only heat available for superheating the steam is that contained in the gases after leaving the evaporating tubes.

The Baldwin Locomotive Works have furnished particulars of a test on this superheater conducted on the Chicago, Rock Island & Pacific Railway. The engine tested was a consolidation weighing 237,000 pounds, of which 210,000 pounds was on the drivers, and the principal dimensions as follows:

Cylinders	22 by 28 in.
Valves	Slide balance
Boiler, type	Straight
Boiler, diameter	80 in.
Boiler, pressure per square inch	163 pounds
Firebox, length	120 in.
Firebox, width	72¼ in.
Heating surface, firebox	179 sq. ft.
Heating surface, tubes	3,658 sq. ft.
Heating surface, total	3,837 sq. ft.
Driving wheels	63 in.

The test consisted of six runs on the Illinois Division between Blue Island and Silvis, a distance of 158 miles, and six on the El Paso Division between Delhart and Tucumari, a distance of 93½ miles. The general averages of the results obtained were as follows:

GENERAL AVERAGES.

	Illinois Div.	El Paso Div.
Number of cars	45 loaded-25 light	37 loaded-21 light
Weight of train exclusive of weight of engine and tender	2,327.0 tons	1,833.4 tons
Number of stops	14.7	3.8
Time consumed in stops	3 hrs. 16 min.	1 hr. 33 min.
Total time of run	12 hrs. 57 min.	6 hrs. 29 min.
Speed	16.1 M. P. H.	15.5 M. P. H.
Indicated horse-power	821.5	891.6
Weight of coal (losses substracted)	33,987.0 lbs.	15,752.6 lbs.
Weight of coal per indicated horse-power per hour	4.23 lbs.	3.86 lbs.
Weight of coal per ton mile	.091 lbs.	.119 lbs.
Weight of water (losses substracted)	217,706.3 lbs.	97,267.7 lbs.
Weight of water per indicated horse-power hour	27.5 lbs.	22.6 lbs.
Weight of water per ton mile	.597 lbs.	.721 lbs.
Equivalent evaporation	7.86 lbs.	7.54 lbs.
Superheat (from initial pressure of cards)	48.8° F.	56.44° F.
Superheat (from boiler pressure)	24.63° F.	33.20° F.
Temperature of steam chest	386.3° F.	403.6° F.
Boiler pressure	154.4 lbs.	159.8 lbs.
Tractive effort	21,375.0 lbs.	24,404.7 lbs.
Length of run	157.0 miles	74.5 miles
Coal per square foot of grate surface per hour	57.6 lbs.	54.9 lbs.

During the first two runs on the Illinois Division the temperature of the front-end gases in front and back of the superheater were shown to be 534° and 635° F., showing a drop of 101° in passing through the superheater. An interesting comparison was also made by taking the temperatures of the steam in the valve chest of a simple consolidation, which averaged 24° below that corresponding to saturated steam at the boiler pressure, so that the superheater, which showed an average temperature in the steam chest of from 25° to 33° above that corresponding to the boiler pressure, may be assumed to have raised the temperature of the steam 50° to 60°.

No comparison was attempted on these tests, but the Baldwin Locomotive Works conclude from the results obtained in a test of a balanced compound and simple engine in passenger service, and from the results of the tests at St. Louis, that a locomotive of this type equipped with a superheater will give a saving of 15 per cent. in water consumption and 11 per cent. in fuel consumption over a similar simple expansion engine. An interesting comparison made during the test was the increase in tonnage that could be handled by the superheater in proportion to the simple engine, and the absence of water in the cylinders, resulting in decreased trouble with the rod packing. No trouble was experienced in the lubrication of the balanced slide valves with the ordinary sight feed lubricator.

With the exception of the more extended application of the "Vauclain" superheater during the past year, evidently but little interest has been manifested in superheating, and yet the replies from those roads on which superheater engines have been in service do not condemn them. The Great Northern Ry., which has one passenger and one freight engine equipped with the "Schmidt" smoke-tube superheater, reports two coal tests between the superheater engines and simple engines of practically identical construction.

In passenger service a test on the Kalispell Division showed a saving of 13 per cent. in water and 14½ per cent. in coal per car mile, while in freight service on the Willmar Division the saving was 30½ per cent. in water and 28½ per cent. in coal per ton mile, the coal figures being 137½ for the simple and 98 pounds for the superheaters per 1,000 ton miles, both very satisfactory figures for Prairie type engines in freight service on an

* For drawings see AMERICAN ENGINEER, March, 1907, page 88, and August, 1907, page 301.

undulating road. They also report a comparison for nine months between a superheater freight engine and a similar simple engine, showing 137 pounds of coal per 1,000 ton miles for the superheater against 171 for the simple, and a cost for repairs of 4 cents per mile against 3.87 cents, a reduction in the coal consumption of 20 per cent. with practically the same cost for repairs.

The Boston & Maine reports on one passenger engine equipped with the "Cole" superheater, that while the original arrangement gave them considerable trouble from leaking and from breakage of the superheater pipes near the header castings, when the engine was in good condition, it has given excellent service, and they are taking steps to substitute improved details. They favor further improvement until better results are obtained rather than the abandonment of superheating.

The Chicago & North-Western Ry. reports with reference to one passenger engine with the original "Cole" superheater, which originally gave trouble from header joints leaking, that by the substitution of ground header joints this trouble has been overcome, and states that the results have been very satisfactory the last twelve months.

The New York Central reports on one passenger engine equipped with the "Cole" superheater, a slight reduction in the coal consumption but no conclusion.

The Soo Line reports on one freight engine equipped with the original "Cole" superheater, that they have experienced no trouble except with leaks in the header connections, and while they cannot give accurate figures showing consumption of coal, there is evidently a saving, and the engine handles a train better than other engines.

The Lake Shore & Michigan Southern Ry. reports on two passenger engines, one equipped with the original "Cole" and the other with the "Vaughan-Horsey" superheater, that no further tests have been made. They have experienced difficulty in their operation as follows:

1. The lubrication. This was first attempted with the forced feed lubricator, and afterward the ordinary sight-feed lubricator was found to give entire satisfaction.

2. On the "Vaughan-Horsey" superheater the top header broke, due to faulty design, which has been overcome by changes in the cross section from square to round.

3. A number of the superheater tubes have cracked, but no remedy has been suggested.

Their conclusion is that the superheater passenger engines have on the whole been satisfactory, and that while certain defects have developed, they are not of a nature that presents any serious difficulty. The engines have proved distinctly superior to simple engines of corresponding types both in economy in fuel and their capacity for handling their trains. They consider superheating a very promising improvement and intend to apply it to a considerably greater extent.

The Canadian Pacific Railway, which, as this report states, has a large number of superheater engines in service, is operated in two systems, the Lines East and West of Fort William respectively, and Mr. Grant Hall, superintendent of motive power of the Lines West, has furnished a report from the master mechanics of the three divisions under his charge, having a total of 103 superheater engines at the commencement and 143 at the end of the year. As these statements cover a fairly extended experience with the original "Cole," "Schmidt" and "Vaughan-Horsey" superheaters, extracts from them are quoted as follows:

"We experience trouble in keeping large superheater tubes free and clear from cinders; if this is not done the benefit of the superheater is lost. I find that the large tube fills up and becomes choked, starting from fire-box end and extending about two feet in it if not kept after and cleaned out regularly; to do this we pull back the deposit with a rod with a bent end and then finish up by blowing through air. We also find that the small steam pipes get coated with soot, which also prevents us getting full benefit of the heat passing through the tube, which is only partly overcome by repeated blowing out with air.

"The 'Schmidt' type is giving us very little trouble on this division, perhaps not so noticeable on account of only having one engine of this type. The main top header on this engine, however, has failed twice by cracking around the neck between the header and the flange which bolts to tube sheet. The jointing arrangement of small superheater pipes has not given us any trouble whatever from leaking or slackening back, which is frequent with other types.

"The 'Cole' type is a constant trouble from leakage at joints where small headers bolt to main header and cannot be maintained tight for any length of time. In tightening them up, which is frequently done, the studs, which were enlarged from ¾ to ⅞ inch, are strained, broken and pulled out from main header. When leaking, the flat face on main header as well as the grooved bed in the small headers are cut by steam leaks, necessitating plugging, etc., making it very costly to maintain, not saying anything about holding engine out of service or extra fuel consumption.

"The 'Vaughan-Horsey' type causes trouble by the union joints leaking, caused by nuts slackening off them where joined to main header, and have to be opened up as often as business will permit and gone over to avoid failures; this being the only trouble we have with this type outside of the returns burning out occasionally, which is equal on all types."

"I am in favor of superheated steam in both passenger and freight service, and consider that we get good results when the arrangement is working satisfactorily and free from leaks. The system should be improved on to lessen the maintenance work, and the question of lubrication most thoroughly gone into with a view of reducing the number of piston and valve rings that are being used. With the quality of the oil we are using we find it necessary to renew piston rings every four or five weeks and the valve rings every two months. When piston rings are removed, if not broken, they are worn down to about ⅜ inch thick. Have had very little difficulty with respect to superheater tubes stopping up, but it is absolutely necessary that the damper in smoke-box be kept in working order.

"With the 'Schmidt' superheaters we experience considerable difficulty in keeping flange joints tight where bolted on header. Have had one header broken off close outside of flange where bolted on to round head. With the 'Vaughan-Horsey' type we have quite a lot of trouble with the brass ring nut at connections, but using the mild steel nut, I think, will overcome this to a great extent.

"My experience with superheated steam in freight service is satisfactory; have no engines in passenger service equipped with superheated steam.

"In regard to the superheater tubes blocking up in the smoke tube class. We have had some difficulty in keeping the smoke tube clean, and the only way to get good results is to blow them out each trip with air; doing so we have been able to keep them in good condition.

"We have had considerable trouble with the piston and valve rings of the superheater type. This trouble has been eliminated to a large extent by making a more rigid examination of rings and feed attachments to valves and cylinders, also by making a perfect fit of new rings when applied to piston. Another important feature toward the maintenance is the superheater dampers and their attachments. To keep these in working condition it is necessary to inspect them thoroughly every week, which will prevent any trouble from defective dampers. The worst feature is the possibility of engine failures on account of superheater pipes bursting and leaking; they give no warning and it is impossible to detect them before giving out.

"In connection with superheaters in freight service, the only difficulty was in the large tubes leaking badly, making it necessary to expand them every round trip. In passenger service I consider them very satisfactory, both in efficiency for this class of work and for the light maintenance of same."

Mr. Hall has also written a general statement of his experience from which the following are extracts:

"We find that the superheater tubes plug up to a certain extent, but we overcome this by blowing out with air. The 'Cole' type only has given us trouble maintaining header joints. In passing I might say, for your information, that the 'Cole' superheater has given us so much trouble in this respect that I would not recommend its use. We have had very little trouble with the 'Schmidt' type, the principal trouble being one that can be overcome, namely, the cracking of the superheater header through the neck. The only difficulty that has been experienced with the 'Vaughan-Horsey' has been the slackening off of the nuts coupling up the superheater pipe to the header; this type of superheater is an easy proposition to maintain.

"In regard to lubrication. We have had nothing in the shape of forced feed that gave satisfaction, and have none now in service, being replaced entirely by sight-feed lubrication. It is not necessary that we have separate cylinder connections, but I do consider it necessary to have connection to each end of the valve bushing when using superheated steam. My experience with superheated steam in both passenger and freight service is satisfactory."

On the Lines East of the Canadian Pacific, for which the chairman of the committee is reporting, practically the only superheater in use is the "Vaughan-Horsey," as those with the "Schmidt" are on Lines West and most of the original "Cole" have been converted.

The important question during the past year has not been one of economy but of maintenance, not with respect to cost, for in that respect the addition of a superheater is not noticeable, but with respect to reliability. Engine failures are annoying and expensive, and no device can be a permanent success which introduces them to any extent. The important troubles that have developed during the last year have been three in number:

1. Leakage at the union connections between the superheater pipes and the header due to nuts slackening off.
2. Bursting and splitting of superheater pipes.
3. Breakage of superheater header.

Leakage at the union connections was at first caused by brass nuts having been used, and with the change to steel nuts it appeared to have ceased. Considerable trouble has, however, been experienced with the steel nuts, although not universally, as on some divisions it is practically nil, but in many cases the nut has

slacked off entirely, causing a complete and annoying failure. The reasons appear to be poor workmanship and insufficient strength of the nuts. With stronger nuts and proper workmanship, both of which can be arranged for, this trouble should be overcome, but it has been decided to apply lock nuts of which several designs are now on trial, which will without a doubt overcome the difficulty; and while a monthly inspection is required, failures from this cause will be avoided.

Bursting and splitting of superheater pipes, while not frequent, can be avoided only by proper maintenance of the dampers. This defect does not occur frequently, and is no doubt partly due to insufficient care having been taken in putting up the pipes to the correct lengths.

Breaking of superheater headers, while not frequent, has occurred several times, but can be stated definitely to be a defect in design.

Only top headers have broken and these all in practically the same place, at the junction of the steam-pipe flange with the header. By changing the form and insuring a stronger metal, there is little doubt of this trouble being overcome.

The number of failures from the above causes have not on the whole been excessive. From April 1, 1907, to January 31, 1908, thirty-nine superheater engines in passenger service made a total of 1,382,820 miles with a total of fifteen failures. Of these nine were due to joints leaking, four to pipes bursting and two to headers breaking. The number of miles per engine failure was therefore 92,188, and as eleven of these failures are from causes that can be overcome it is evident that when this is done the unavoidable failures are not a serious drawback.

Figures are not available giving the failures in freight service with any degree of accuracy, as if the records were taken as they stand they would show so small a number of failures that their unreliability would be evident, but those in passenger service are reasonably correct.

So far as the cost of repairs is concerned the addition of a superheater does not appear to be noticeable. The superheater itself certainly costs something to maintain, as do the necessary inspection of its parts, but the net result is, so far as the records on the Canadian Pacific Ry. are concerned, in favor of the superheater as against any other class of engines, and there is no evidence whatever of increased cost.

While discussing the difficulties introduced by the application of superheaters there are certain advantages which to a large extent offset them. Where simple engines have been converted, they have shown an increase in capacity that may be roughly estimated at about 10 per cent. They run more freely, and are decidedly easier on their fire, allowing an inferior grade of coal to be burned with less difficulty, to an extent which caused a superheater passenger engine to handle trains without loss of time when similar simple engine failed to do so. There is also a notable absence in superheaters of the trouble caused by water, and on the whole, providing the difficulties mentioned are overcome, it is a close question whether superheater engines will not average less failures than a corresponding number of simple engines, and they will certainly handle heavier trains and make time. Where coal is expensive and the question is one of the adoption of a compound or a superheater, there is no doubt that the latter will give greater economy, with a smaller cost for repairs and less trouble.

The results in fuel consumption appear to confirm the statements made in the last report, namely, 10 to 15 per cent. in freight service and 15 to 20 per cent. in passenger service. It does not appear necessary to present these figures in detail, as this has been done in previous years, but the results for July to December, inclusive, have been gone over by sections and months, those cases being selected in which sufficient work was performed by the two classes of engines being compared to render the results reasonably reliable.

The equivalent coal is the coal which the class of engine shown would have burned had its consumption per ton mile been equal to that of the class taken as the basis of comparison, while its relative consumption is the proportion of the actual to the equivalent coal. As these quantities are calculated month by month and the traffic and weather conditions thus equalized, this method is comparatively accurate.

The comparison of simple consolidation engines class M-4b with similar "Vaughan-Horsey" superheaters is shown in Table 1, from which the average consumption of the simple engines works out at 113½ per cent. of that of the superheaters.

The consumption of compound ten-wheel freight engines D-9 and "Cole" superheaters, D-10c with "Vaughan-Horsey" superheaters, is shown in Table 2, from which the average consumption of the compound engines works out at 100 per cent. and that of the "Cole" superheater at 107 per cent. of that of the "Vaughan-Horsey" superheater.

Table 3 shows the comparison of Pacific type superheater engines, Class G-2, and of ten-wheel superheater, E-5g with ten-wheel simple engines, Class E-5. The ten-wheel superheaters are engines converted from simples and are otherwise similar. From this table the saving in fuel on the converted engine works out at 21 per cent. and that of the Pacific type at 22½ per cent. on Lines East, but this figure is subject to the larger engine doing more work for the same weight of train or handling heavier trains, although only certain sections have been included where this variation is a minimum. The results on the Brandon and Swift Current sections are remarkable in view of the large amount of coal burned, and show, with a total of 5,250 tons, a saving of about 35 per cent.

TABLE 1.

SECTION.	Class.	Coal. Actual.	Coal. Equivalent.	Relative Consumption.
				Per Cent.
Farnham	M-4b	2.999	2,683	112
Newport	"	1,121	885	127
Havelock	"	86	80	107½
Toronto	"	2,385	2,162	108
London	"	618	546	113
North Bay	"	1,204	1,052	114
All	"	8,413	7,408	113½

TABLE 2.

Ignace	D-9	885	862	103
Kenora	"	781	781	100
Brandon	"	1,079	1,110	97½
All	"	2,745	2,753	100
Ignace	D-10c	2,030	1.920	106
Kenora	"	9,012	8,288	109
Winnipeg	"	15,498	15,537	99½
All	"	27,540	25,745	107

TABLE 3.

North Bay	G-2	246	177	72
Chapleau	"	364	270	74
White River	"	363	308	83
All	"	973	755	77½
Brandon	"	2,753	4,169	66
Swift Current	"	2,496	3,890	64
North Bay	E-5g	555	704	79
Smith's Falls	"	990	1,281	77

The replies show that the question of lubrication appears to have been settled by all roads resorting to the sight-feed lubricator.

Two roads report satisfactory results with a single central connection to the valve chest as on ordinary simple engines, but the majority are using the separate cylinder connection with either one central or two separate connections to the valve chest.

On the Canadian Pacific some engines are running with one central connection to the valve chest and no cylinder connection, but the preferred arrangement is the separate connection to the cylinders with one feed to the valve chest split to feed to both ends. The cylinder connection feed is generally cut down to a very small amount when running and most of the oil fed through the valves, but the majority of the men prefer to have it in case it is required.

Tests of Briquetted Coal.

By A. W. Gibbs.

These tests were carried out under the direction of Dr. J. A. Holmes, Expert in Charge, Technologic Branch, United States Geological Survey, at the locomotive testing plant of the Pennsylvania Railroad at Altoona.

It was intended to ascertain if low volatile coals of a semi-smokeless nature but friable and, therefore, not fairly satisfactory in locomotive use, could, when briquetted, be used to reduce the amount of smoke and prevent the loss sustained from the discharge of cinders, which is large in coals of this character.

The coal selected had the following proximate analysis:

Fixed carbon	73.21 per cent
Volatile combustible	17.75 per cent
Moisture	2.43 per cent
Ash	6.61 per cent
	100.00 per cent
Sulphur	1.34 per cent
Calorific value, B. T. U.	14918

A series of tests was run with the raw coal and another series with the same coal briquetted in two forms, square and round,

and experiments were made with the percentage of binder from 5 per cent. to 8 per cent. All tests were run on the locomotive testing plant, a simple cylinder Atlantic type locomotive being used, having a total heating surface including fire side of tubes of 2,320 square feet and a grate area of 55.5 square feet.

The series with the raw coal was run in such a way as to show the full performance of the boiler from low rates of evaporation to the highest possible rate of evaporation. The lowest rate of evaporation was about 18,000 pounds of water per hour, equal to 8 pounds per square foot of heating surface; this being increased throughout the test until, with the briquetted fuel, an evaporation of 44,500 pounds of water from and at 212° F. was obtained. This is equivalent to 19 pounds of water per hour per square foot of heating surface. The briquettes were fired with ordinary shovel and handled in the manner usually employed for coal, no necessity being found for breaking them.

The following table taken from a plot of actual results shows comparatively the evaporation of the natural and briquetted coal.

When the rate of evaporation per square foot of heating surface is, pounds.	The equivalent evaporation per pound of fuel is, for	
	Natural Lloydell coal, pounds.	Briquetted coal, pounds.
8	9.5	10.7
10	8.8	10.2
12	8.0	9.7
14	7.3	9.2
16	6.6	8.7

The quantity of cinders collected in the smoke box showed no material difference as between the raw coal and the briquetted coal. The quantity collected per hour when burning 100 pounds of fuel per square foot of grate was about 400 pounds, reaching a maximum of about 750 pounds per hour with the coal being burned at the rate of 120 pounds per square foot of grate. Firebox and smoke-box temperatures were practically the same at the same rates of evaporation, whether the coal was used in its raw state or briquetted.

The apparent reason for the increased evaporation per pound of fuel with the briquetted coal is that, although, as already stated, the loss due to cinders in the smoke box is not different as judged by the quantity collected, the calorific value of the cinders from the briquetted coal was lower than with raw coal, and, further, on account of the uniform size of the briquetted fuel the distribution of air through the fire permitted more complete combustion and liberation of heat than with the raw coal.

The fuel consumed per draw-bar horse-power with the locomotive running at a speed of 37.78 miles per hour and a cut-off of 25 per cent. was as follows:

Raw coal	4.48 pounds
Round briquettes	3.65 pounds

This is equivalent to stating that the amount of briquetted coal was 81 per cent. of the amount of raw coal required per draw-bar horse-power at this speed and cut off.

Smoke observations were made by Ringelmann's method and by photographs. By this former method no smoke is indicated by 0 and very black smoke by 5, there being a total of six gradations from 0 to 5 inclusive. The following table indicates for a portion of the speeds and cut-offs the comparative smoke readings, these being an average of a large number of observations made at regular intervals.

Speed, miles per hour.	Cut off.	Average smoke.	Kind of fuel.
	Per cent.		
28.34	20	1.2	Raw coal.
28.34	20	0.8	Round briquettes.
37.78	25	1.8	Raw coal.
37.78	25	0.7	Round briquettes.
37.78	30	2.1	Raw coal.
37.78	30	1.8	Round briquettes.

It is evident from the above that the briquetting of this coal materially reduced the amount of smoke, but it could not be determined whether the difference in percentages of binder used made any difference in the smoke produced.

At the end of one test at about 37 miles per hour and a cut-off of 32 per cent., the locomotive was shut off and the blower put on and at the end of two minutes the smoke had entirely cleared from the stack. Various supplemental tests indicated that with care the locomotive could be brought into a terminal where smoke was objectionable by the proper use of blower and judgment on the part of the engineman in regard to the amount of fuel in the shape of briquettes fed to the fire. There was no difficulty in starting the fire with briquettes, the same method being used as with the raw coal.

To determine the effect of weathering, a number of round and square briquettes were placed on the roof in January and February and examined in May or about four months after, and these showed no change whatever in their condition.

For these tests, the briquettes which had been made at the station of the Geological Survey were shipped to Altoona carefully stacked in open gondola cars and were carefully unloaded and restacked. Very few were broken and the amount of fine coal abraded from the surface was practically negligible. This method of handling was all carefully done, but if the briquettes had been shipped for regular locomotive service it is not thought that the breaking and abrasion, due to handling briquettes, would be a serious matter for regular service.

Subjects.

Committee—C. A. Seley (chairman), D. F. Crawford, L. R. Pomeroy.

The committee suggests the following subjects for committee work for the 1909 convention:

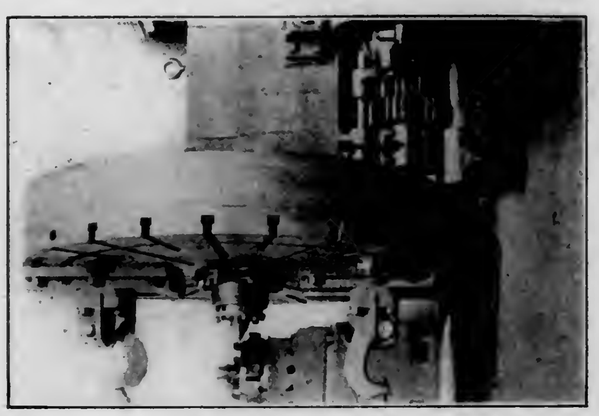
1. The organization best suited to obtain economical results in maintenance of locomotives. Le Grand Parish, H. D. Taylor, D. J. Redding, A. Forsythe, S. J. Hungerford, H. W. Jacobs.
2. Driving pressure for firebox rivets and the advantage of avoiding seams in locomotive crown sheets. W. F. Kiesel, J. H. Manning, W. A. Robb, H. H. Maxfield, G. Wagstaff.
3. Use of plug and ring gauges for all important fits. R. N. Durborow, A. Stewart, L. H. Turner, H. B. Ayres.
4. Ash pits and ash handling plants; the best and most efficient arrangement. H. S. Hayward, W. Manchester, F. H. Clark, John Howard, H. M. Curry.
5. Rolled steel wheels. A. S. Vogt, H. Bartlett, J. E. Muhlfeld, C. H. Quereau, G. W. Wildin.
6. Standard rules for testing boilers and stay bolts. J. T. Wallis, T. A. Foque, M. E. Wells, M. H. Wickhorst, W. C. A. Henry.
7. Standard limits governing the wear of locomotive tires, as concerns height and thickness of flange and depth of channeling. E. D. Bronner, Robt. Quayle, R. K. Reading, C. E. Fuller, J. T. McGrath.
8. Advantages of water purification as a means of decreasing cost of locomotive repairs and reducing failures on the road. W. C. Arp, H. Stillman, G. H. Emerson, R. D. Smith, E. B. Thompson.
9. Investigation as to the most desirable composition of material for locomotive driving wheel tires, and adoption of standard grades for various classes of service. T. W. Demarest, W. R. McKeen, J. A. Carney, W. A. Nettleton, F. M. Whyte, C. B. Dudley.

INDIVIDUAL PAPERS.

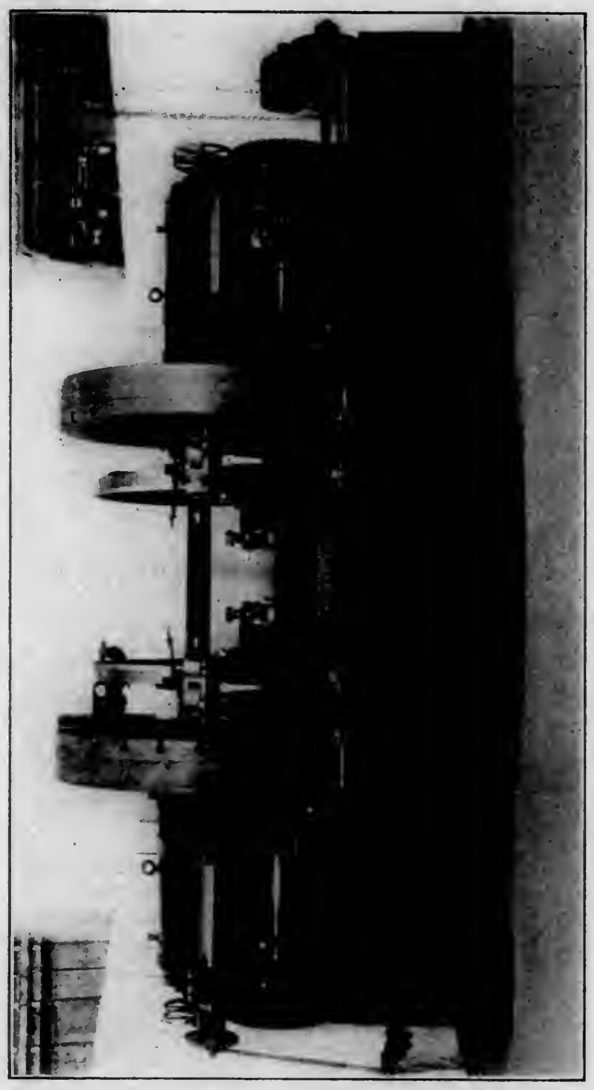
1. Heat transference of tubes and plates. Prof. Charles Edward Lucke, Columbia University.
2. Crane hooks: results of exhaustive experiments and recommendations as to design. Prof. Walter Rautenstrauth, Columbia University.

VALUE OF SPECIFICATIONS TO PURCHASING AGENTS.—Many purchasing agents spend half their time trying to secure further definite information than is ordinarily furnished at first in regard to supplies they are asked to buy. They do this in order to have some specifications, even though crude, as a fair basis on which to compare bids and place orders, which will insure to some extent the railroad company's receiving the quality, sizes and kinds of supplies best suited for its requirements. If, therefore, a purchasing agent is supplied with definite and complete specifications and drawings prepared by experts, covering many of the most important articles purchased, the result is certainly a great relief to the purchasing department. It simplifies the work there, not only at the time purchases are made, but later also in lessening the amount of correspondence complaining about defective devices or inferior workmanship or material.—*W. V. S. Thorne before the New York Railroad Club.*

THE VALUE OF OUR MANUFACTURED PRODUCTS.—In 1905 the value of the product of our manufactures amounted to $16,866,706,985; the total receipts of the steam railroads were $2,325,765,167. In manufacturing, the value of the product was $1,152 for each horse-power installed and the yearly wages amounted to $248 per horse-power. In the railroad industry, the gross receipts amounted to $555 and the yearly wages to $224 per horse-power, rated on a basis comparable to that used in the census report covering manufactures.—*H. St. Clair Putnam before the Conference on the Conservation of Natural Resources.*

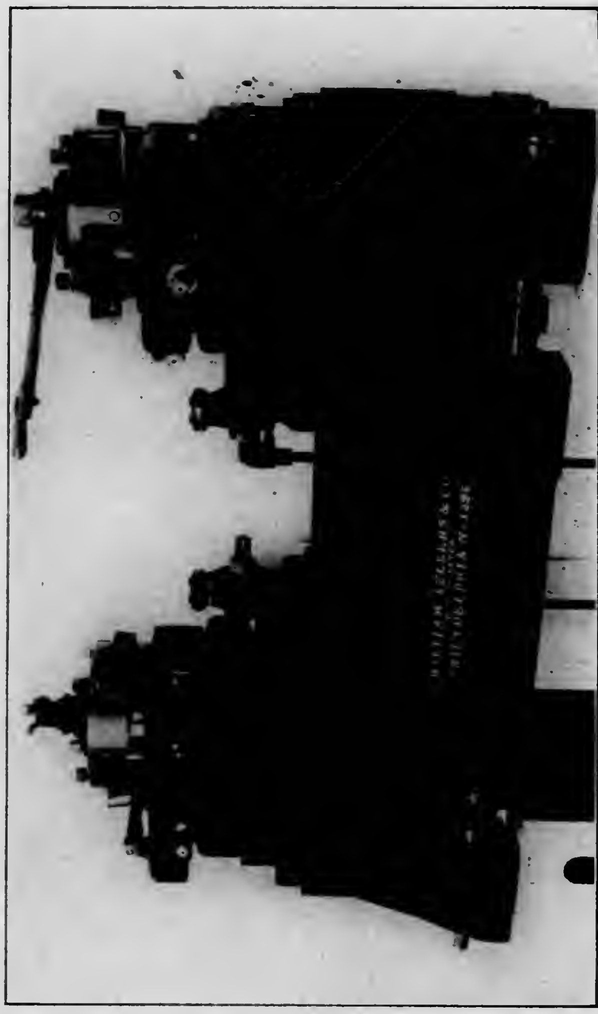


VIEW OF FACE PLATE FROM REAR SHOWING DRIVERS LATCHED (TOP) AND UNLATCHED.

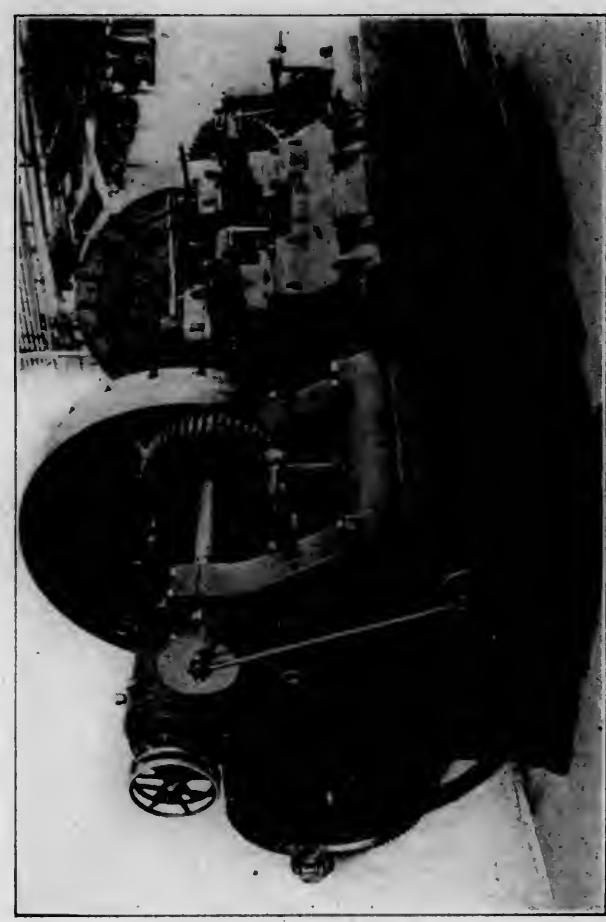


FRONT VIEW OF HIGH POWER WHEEL LATHE SHOWING A PAIR OF WHEELS IN POSITION. MOTOR ON EXTREME RIGHT IS FOR ADJUSTING THE RIGHT HAND HEAD.

VIEW SHOWING WHEEL CLAMPED BY DRIVER. NOTE PROVISION FOR ADJUSTING THE DRIVERS.



VIEW SHOWING TOOL BENCH, TURRETS AND RESTS. NOTE THE MICROMETER SET SCREW AND TURNOVER STOPS FOR SECURING UNIFORMITY IN THE TWO WHEEL DIAMETERS.



GENERAL VIEW OF SELLERS HIGH POWER WHEEL LATHE SHOWING LEFT HAND HEAD AND DRIVING MECHANISM.

A NEW HIGH POWER WHEEL LATHE.

The improvement in wheel lathes during the past three or four years has been continuous and has constantly continued to cut down the time of turning a pair of locomotive driving wheels until it has been reduced to such a point that the time lost in handling and setting the work and changing the tools has become relatively of much greater importance. It is now clearly evident that any further noticeable improvement in increasing the output of wheel lathes must be looked for in the direction of reducing the time and labor of performing these operations rather than increasing the size of cut or the cutting speed. Recognizing this condition, William Sellers & Co., Philadelphia, have developed a design of wheel lathe which, while having all the necessary power and stiffness to take the heaviest practical cuts, possesses a number of new features, which greatly facilitate the handling of the work and the tools.

The illustrations on the opposite page show the general appearance and several of the more prominent new features of an 80-inch lathe of this design. It will be noted that the machine is very massive in construction and convenient in arrangement. The driving power is obtained from a motor located back of the left hand head, which transmits the power through pinions and gears to a very large driving shaft, provision being made for two mechanical changes of speed. This long driving shaft, noticed just below the face plate in the upper left hand illustration, transmits the power to the face plates through two reductions of gearing, the final pinion driving the face plates being located in nearly the same horizontal plane as the tools and on the same side of the center. In this manner the tool loads are transmitted directly through the face plate and drivers without imposing any pressure on the spindle bearings. The mechanical speed changes are operated by the handle shown in the front of the left hand head.

Possibly the point of greatest interest in this machine is the drivers which hold the wheels to the face plate. This new form of driver has been designed with the object of obtaining a construction which will securely lock the wheels against the pressure of the heaviest cuts without side strains on the wheel rims, and will also hold with a resistance proportional to the cut. It was also desired that the drivers should be self-contained and have no loose parts to be removed or replaced in changing wheels. As can be seen in the illustrations, these objects have been fully attained. The drivers grasp the inner and outer faces of the tire, holding it securely without any side straining; they are clamped entirely by one set screw, which can be tightened with an ordinary short wrench and are provided with a side play which is utilized for producing a toggle joint effect, resulting in the driving power being increased proportionally to the resistance of the cut. The clamping arm is pivoted to a floating block and is arranged with a latch which holds it in the open position after being released and allows the wheels to be removed without interference. Each driver is mounted in a swinging frame or plate secured to the face plate of the lathe, which permits them to be conveniently adjusted to suit the diameter of the wheels, location of crank pins, number of spokes, etc. The most rigid tests have shown this new type of driver to be entirely successful in every particular.

Another very interesting new feature of this lathe is found in the turret tool holders, which are clearly shown, as mounted on the tool bench, in the lower left hand illustration. The turrets are arranged for carrying four finishing tools and the center clamping bolt has a transverse opening which allows a long bar of tool steel to be used for the roughing tool. The other tools not being subject to so frequent renewals can be made conveniently with short shanks. The turret is rotated by a ratchet hand lever and when the various working positions are reached a spring latch holds it in place. A further motion of the hand lever then clamps it firmly.

The front of the openings in the turrets for the forming tools is made with a slight taper to fit a corresponding taper on the tool socket. The tools are thus accurately centered and securely held against side motion, and it also permits a reduction in the size of the tool body without decreasing the broad bearing surface which supports the cutting edge.

The turrets are mounted on slide rests, which are of very heavy construction and are set low. They are carried on a bench adjustable by racks and pinions to suit the diameters of the wheels. The base of the slide rest is arranged to swivel on the bench to suit the angle of the wheel tread. The slides are each provided with a feed ratchet, the connections for which are fitted with ball joints. A convenient micrometer screw and stop on the side of the cross slide enables the wheels to be rough turned to the same diameter without calipering. The stop can be swung aside while finishing.

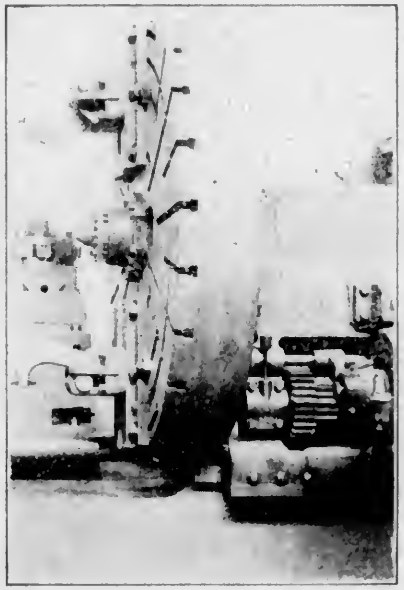
The spindle caps on the heads are worthy of attention and are made in one continuous piece, providing a nearly solid support for the hardened steel step, which is placed at the end of the spindle for taking end thrusts. Secured to the face plates are flanged bearings through which the sliding spindles pass, greatly reducing their overhang when supporting the work. These bearings are supplied with split tapered bushings for taking up wear, and to maintain an easy fit without lost motion.

Speed changes, both mechanical and electrical, are provided which give spindle speeds varying from 3/8 to 1½ turns per minute with numerous intermediate steps. The right hand head is operated along the bed by a small motor located on the bed plate and shown at the extreme right of the center picture in the upper row. A lever is provided for disengaging the driving pinion when it is desired to change the relation of the face plates, as when changing from a right to a left hand lead.

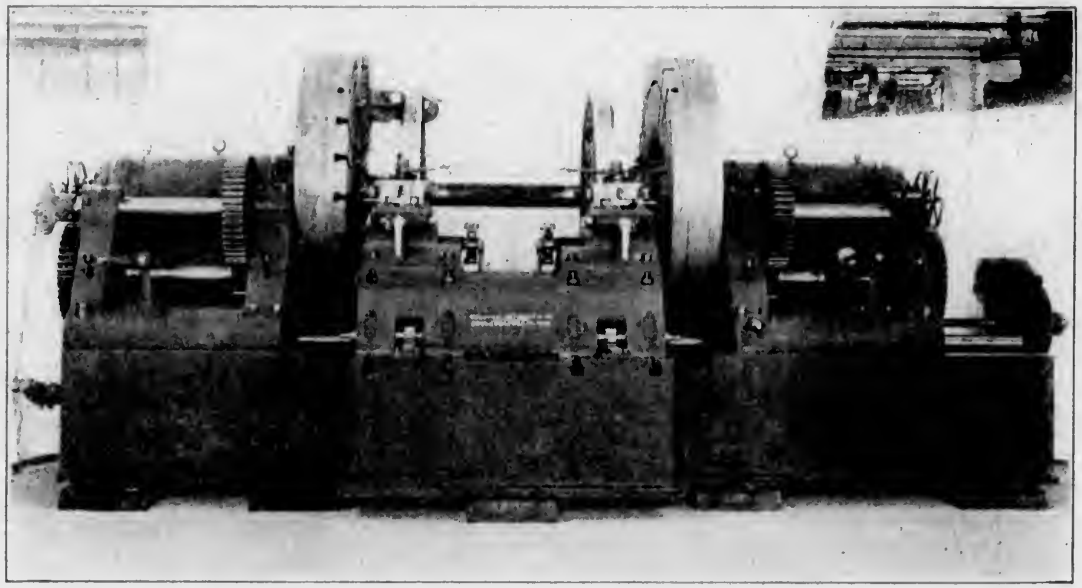
A test was recently made with one of these machines at the Sellers plant, in Philadelphia, which, in spite of the fact that the machine was operating under a number of disadvantages, such as being mounted on blocks about 4 ft. above its normal level, and also for the lack of facilities for handling the wheels to and from the lathe, which would be provided in all railroad shops, gave some very remarkable results. Three pairs of wheels were turned in two hours and ten minutes, which included a loss of six minutes because of a broken tool. The actual time of turning one pair of wheels, 67 in. in diameter and 6¼ in. face, was 37 minutes. They were released and taken out, lowered to the floor and another pair of the same size were taken up and put into place all in ten minutes. This second pair of wheels was turned in 28 minutes and released and delivered upon the floor in two minutes. The drivers were then changed in position to suit 78 in. wheels and a pair was taken from the floor, put in and clamped fast in three minutes and twenty-two seconds. These wheels had been previously turned and were in a condition of what might be required in truing up a pair of new tires. The actual turning time upon this pair was nineteen minutes. The wheels were taken out and delivered upon the floor and the slings removed in four minutes. In all of this work the treads were turned smooth, *i. e.*, the roughing cuts were entirely obliterated. During this test while taking a cut with 15/32 in. feed, an average depth of 3/8 in., and a cutting speed of 12 to 15 ft. per minute on each of two 78 in. tires, an average of 211 amperes were required by the motor.

The net finished weight of an 80 in. lathe is 115,565 lbs. The address of William Sellers & Co., the builders of this machine, is 1600 Hamilton street, Station "J," Philadelphia, Pa.

CONSERVATISM ON RAILROADS.—Equally restrictive to the introduction of any new device or system on a railway is the extreme element of conservatism that has such a strong hold in the minds of the average railway official, from the heads of departments down to the foremen, and even to the men in the shops; a conservatism fostered by years of unbroken habitude, and firmly established by following devoutly the recurrent routine of daily duties. From this conservatism itself, coupled with a fear of disapprobation should a mistake be made in the adoption of some method or device differing from the old and established régime, springs a destructive criticism which, though it may be given with the object of self-protection, often results in an irreparable loss, both to the object of criticism and to the criticiser.—*H. W. Jacobs in The Engineering Magazine.*



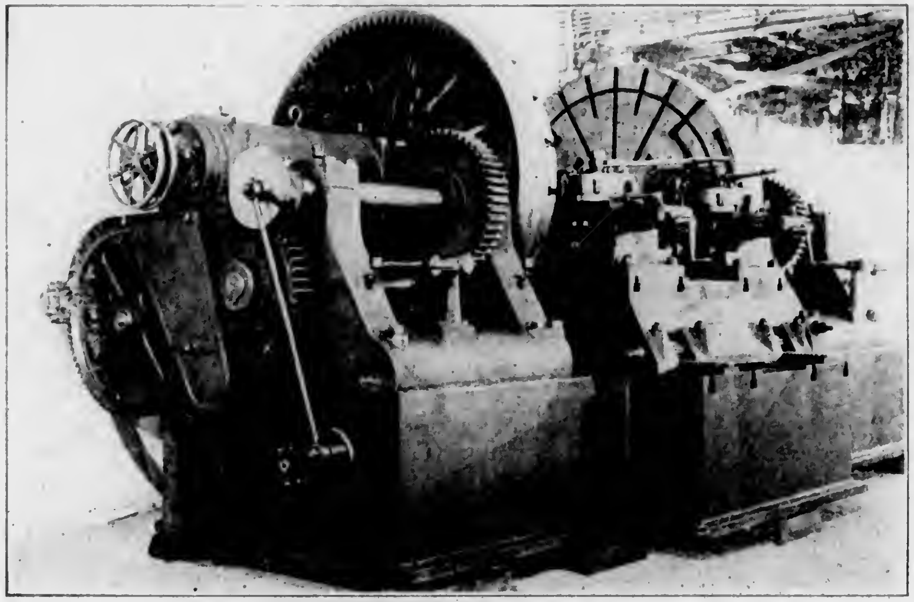
VIEW OF FACE PLATE FROM REAR SHOWING DRIVERS LATCHED (TOP) AND UNLATCHED.



FRONT VIEW OF HIGH POWER WHEEL LATHE SHOWING A PAIR OF WHEELS IN POSITION. MOTOR ON EXTREME RIGHT IS FOR ADJUSTING THE RIGHT HAND HEAD

VIEW SHOWING WHEEL CLAMPED BY DRIVER. NOTE PROVISION FOR ADJUSTING THE DRIVERS.

VIEW SHOWING TOOL BENCH, TURRETS AND RESTS. NOTE THE MICROMETER SET SCREW AND TURNOVER STOPS FOR SECURING UNIFORMITY IN THE TWO WHEEL DIAMETERS.



GENERAL VIEW OF SELLERS HIGH POWER WHEEL LATHE SHOWING LEFT HAND HEAD AND DRIVING MECHANISM.

A NEW HIGH POWER WHEEL LATHE.

The improvement in wheel lathes during the past three or four ears has been continuous and has constantly continued to cut own the time of turning a pair of locomotive driving wheels ntil it has been reduced to such a point that the time lost in andling and setting the work and changing the tools has beome relatively of much greater importance. It is now clearly vident that any further noticeable improvement in increasing e output of wheel lathes must be looked for in the direction i reducing the time and labor of performing these operations ather than increasing the size of cut or the cutting speed. Recgnizing this condition, William Sellers & Co., Philadelphia, have leveloped a design of wheel lathe which, while having all the ecessary power and stiffness to take the heaviest practical cuts, possesses a number of new features, which greatly facilitate the andling of the work and the tools.

The illustrations on the opposite page show the general appearance and several of the more prominent new features of an 80-inch lathe of this design. It will be noted that the machine is very massive in construction and convenient in arrangement. The driving power is obtained from a motor located back of the left hand head, which transmits the power through pinions and gears to a very large driving shaft, provision being made for two mechanical changes of speed. This long driving shaft, noticed just below the face plate in the upper left hand illustration, transmits the power to the face plates through two reductions of gearing, the final pinion driving the face plates being located in nearly the same horizontal plane as the tools and on the same side of the center. In this manner the tool loads are transmitted directly through the face plate and drivers without imposing any pressure on the spindle bearings. The mechanical speed changes are operated by the handle shown in the front of the left hand head.

Possibly the point of greatest interest in this machine is the drivers which hold the wheels to the face plate. This new form of driver has been designed with the object of obtaining a construction which will securely lock the wheels against the pressure of the heaviest cuts without side strains on the wheel rims, and will also hold with a resistance proportional to the cut. It was also desired that the drivers should be self-contained and have no loose parts to be removed or replaced in changing wheels. As can be seen in the illustrations, these objects have been fully attained. The drivers grasp the inner and outer faces of the tire, holding it securely without any side straining; they are clamped entirely by one set screw, which can be tightened with an ordinary short wrench and are provided with a side play which is utilized for producing a toggle joint effect, resulting in the driving power being increased proportionally to the resistance of the cut. The clamping arm is pivoted to a floating block and is arranged with a latch which holds it in the open position after being released and allows the wheels to be removed without interference. Each driver is mounted in a swinging frame or plate secured to the face plate of the lathe, which permits them to be conveniently adjusted to suit the diameter of the wheels, location of crank pins, number of spokes, etc. The most rigid tests have shown this new type of driver to be entirely successful in every particular.

Another very interesting new feature of this lathe is found in the turret tool holders, which are clearly shown, as mounted on the tool bench, in the lower left hand illustration. The turrets are arranged for carrying four finishing tools and the center clamping bolt has a transverse opening which allows a long bar of tool steel to be used for the roughing tool. The other tools not being subject to so frequent renewals can be made conveniently with short shanks. The turret is rotated by a ratchet hand lever and when the various working positions are reached a spring latch holds it in place. A further motion of the hand lever then clamps it firmly.

The front of the openings in the turrets for the forming tools is made with a slight taper to fit a corresponding taper on the tool socket. The tools are thus accurately centered and securely held against side motion, and it also permits a reduction in the size of the tool body without decreasing the broad bearing surface which supports the cutting edge.

The turrets are mounted on slide rests, which are of very heavy construction and are set low. They are carried on a bench adjustable by racks and pinions to suit the diameters of the wheels. The base of the slide rest is arranged to swivel on the bench to suit the angle of the wheel tread. The slides are each provided with a feed ratchet, the connections for which are fitted with ball joints. A convenient micrometer screw and stop on the side of the cross slide enables the wheels to be rough turned to the same diameter without calipering. The stop can be swung aside while finishing.

The spindle caps on the heads are worthy of attention and are made in one continuous piece, providing a nearly solid support for the hardened steel step, which is placed at the end of the spindle for taking end thrusts. Secured to the face plates are flanged bearings through which the sliding spindles pass, greatly reducing their overhang when supporting the work. These bearings are supplied with split tapered bushings for taking up wear, and to maintain an easy fit without lost motion.

Speed changes, both mechanical and electrical, are provided which give spindle speeds varying from 3/8 to 1 1/2 turns per minute with numerous intermediate steps. The right hand head is operated along the bed by a small motor located on the bed plate and shown at the extreme right of the center picture in the upper row. A lever is provided for disengaging the driving pinion when it is desired to change the relation of the face plates, as when changing from a right to a left hand lead.

A test was recently made with one of these machines at the Sellers plant, in Philadelphia, which, in spite of the fact that the machine was operating under a number of disadvantages, such as being mounted on blocks about 4 ft. above its normal level, and also for the lack of facilities for handling the wheels to and from the lathe, which would be provided in all railroad shops, gave some very remarkable results. Three pairs of wheels were turned in two hours and ten minutes, which included a loss of six minutes because of a broken tool. The actual time of turning one pair of wheels, 67 in. in diameter and 6 1/4 in. face, was 37 minutes. They were released and taken out, lowered to the floor and another pair of the same size were taken up and put into place all in ten minutes. This second pair of wheels was turned in 28 minutes and released and delivered upon the floor in two minutes. The drivers were then changed in position to suit 78 in. wheels and a pair was taken from the floor, put in and clamped fast in three minutes and twenty-two seconds. These wheels had been previously turned and were in a condition of what might be required in truing up a pair of new tires. The actual turning time upon this pair was nineteen minutes. The wheels were taken out and delivered upon the floor and the slings removed in four minutes. In all of this work the treads were turned smooth, *i. e.*, the roughing cuts were entirely obliterated. During this test while taking a cut with 15/32 in. feed, an average depth of 3/8 in., and a cutting speed of 12 to 15 ft. per minute on each of two 78 in. tires, an average of 211 amperes were required by the motor.

The net finished weight of an 80 in. lathe is 115,565 lbs. The address of William Sellers & Co., the builders of this machine, is 1600 Hamilton street, Station "L," Philadelphia, Pa.

Conservatism on Railroads.—Equally restrictive to the introduction of any new device or system on a railway is the extreme element of conservatism that has such a strong hold in the minds of the average railway official, from the heads of departments down to the foremen, and even to the men in the shops; a conservatism fostered by years of unbroken habitude, and firmly established by following devoutly the recurrent routine of daily duties. From this conservatism itself, coupled with a fear of disapprobation should a mistake be made in the adoption of some method or device differing from the old and established régime, springs a destructive criticism which, though it may be given with the object of self-protection, often results in an irreparable loss, both to the object of criticism and to the criticiser.—*H. W. Jacobs in The Engineering Magazine.*

AIR COMPRESSORS FOR THE RAILWAY SHOP.

By H. Edsil Barr.

The rapid modernization of the railway shops, in equipment and methods, has included the increased use of compressed air for many purposes. The compressor plant has become of vital importance and there is a demand for a high grade, rugged, and thoroughly substantial compressor equipment capable of giving constant, economical service at high pressure and increased speed compared with the light and uneconomical machine commonly in use a decade past. The machines illustrated herewith have been recently added to the line of air compressors built by the Bury Compressor Company, Erie, Pa., and are specially adapted to railway shop service.

The massiveness and rigidity of these machines are apparent. The frames are of the bored guide type, with heavy duty quarter box bearings, which are tied into the frame body by heavily ribbed, long sweep housings. The air and steam cylinders are held rigidly in line by the circular, internally flanged yoke, which is provided with large side holes for conveniently reaching the stuffing boxes. The machine proper—frame and cylinders, with attached parts—is secured by through and tap bolts to an unusually deep sub-base, which on the two-stage machines includes the intercooler, making the entire outfit self-contained, of permanent alignment and adapted to run as satisfactorily on a good timber cribbing as on a more permanent foundation of concrete or brick.

The crank shafts and connecting rods are of forged open hearth steel. The crank of the duplex machines is of the built up type, with balanced disks forced on the shaft and held by two keys. The pin is forced in and riveted. The various operations in the building up of this crank are done with a care and precision which makes the completed crank practically as solid and true as if made from one piece. The single crank shaft is slotted from a single forging, the pin and journals are turned with large fillets, and the shaft is fitted with counterweighted disks mounted on the wings of the crank by a special construction, the joints being all machined and no babbitt or other soft metal likely to loosen from shrinkage being used.

The connecting rods have the approved marine crank end and solid crosshead end. The crank end boxes are lined with babbitt and the crosshead boxes are phosphor bronze. All babbitt in the main bearings and connecting rods is poured into dovetailed recesses, after which it is piened thoroughly to overcome shrinkage, and the box is bored to fit the pin or journal. The crosshead is of box form, with adjustable shoes and steel wrist pin drawn in on a continuous taper and securely fastened. The careful construction of all bearings and the methods used to insure perfect alignment make these machines remarkably smooth in operation with small friction loss.

The steam valve is a balanced, double ported slide type, having very short steam ports, and is well suited to the operation of a compressor or engine, giving economical service with little attention aside from lubrication. The steam cylinders are lagged with asbestos to reduce radiation, and are covered with a heavy polished blue steel jacket. The cranks of the duplex machine are protected by a polished steel guard with heavy angle iron pieces, and the single crank machine may also be so fitted.

The air valves, the vital parts of any compressor, as ordinarily furnished, are of the automatic, direct lift type, with spring closure, operating in guides of a recently improved form, which possess features worthy of special attention. The most common form of inlet valve guide is made of brass and screwed into the wall of the cylinder or head. This thread is straight, and, being depended upon to a great extent for tightness, is made a good fit in the tapped hole. The guide is made of brass to prevent its corroding to the cylinder metal in the thread, as it would if it was of iron, but as fully an annoying trouble is experienced by the cylinder oil working in around the thread and becoming carbonized from the heat of compression to an extent which makes it extremely difficult to remove the guide. In some cases which have come under the writer's notice it has been necessary to chip the guide out. Some, knowing the possibility of this trouble, have resorted to removing the guides once a week and cleaning with gasoline. This is effective, but the softer thread of the brass soon wears loose from frequent removal, and few operators will go to this trouble. In fact, often the opportunity is not available.

It becomes advisable, therefore, to avoid the necessity of such attention, and the guide adopted accomplishes the purpose admirably. The guide and seat are one piece, an iron casting, which screws into the metal of the cylinder in the cool air

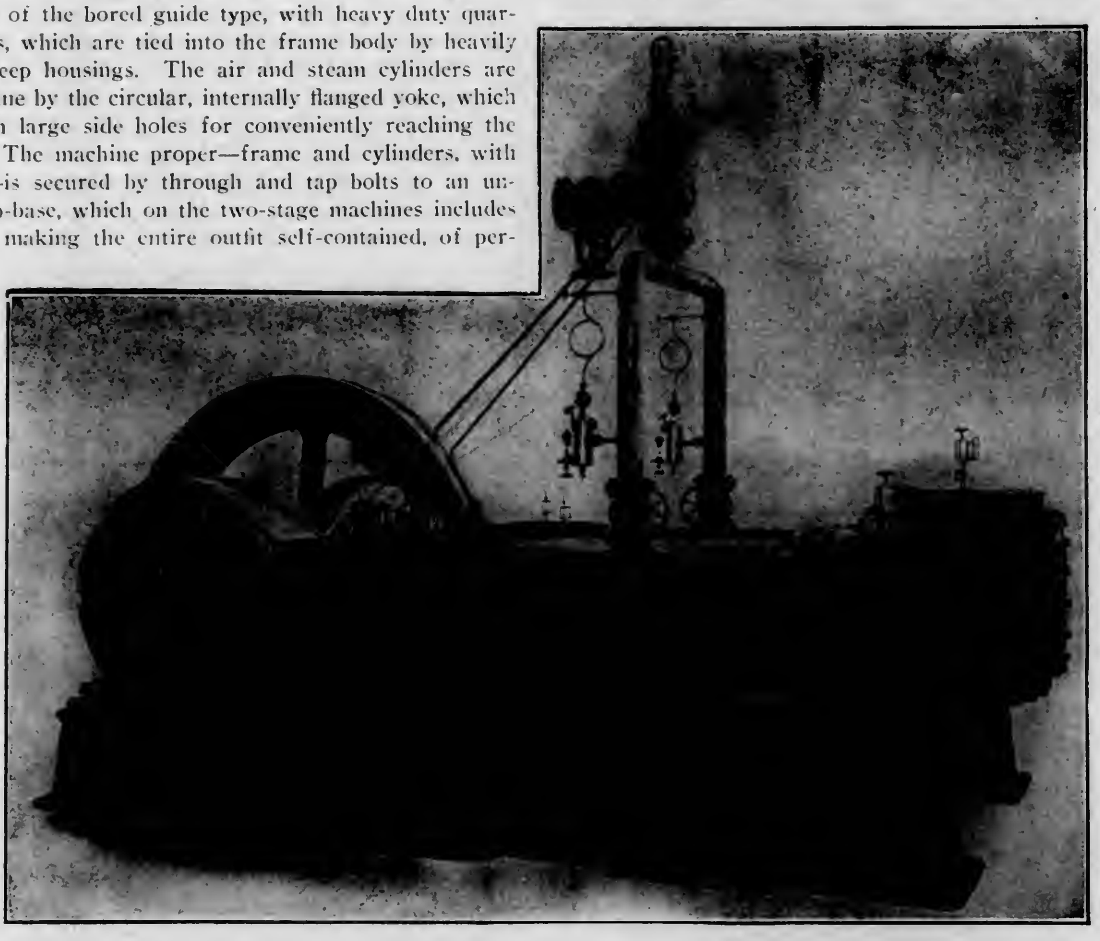


FIG. I.—DUPLEX BURY COMPRESSOR—BUILT WITH SIMPLE OR TWO-STAGE AIR AND SIMPLE OR COMPOUND STEAM CYLINDERS.

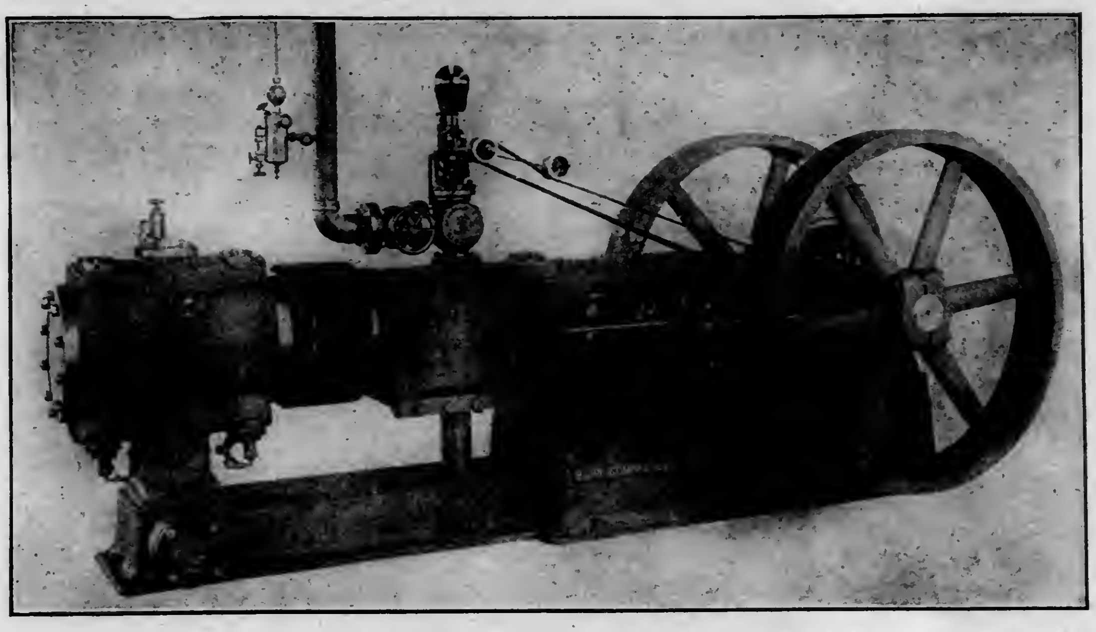


FIG. 2.—CLASS B. S. BURY COMPRESSOR—12, 14 AND 16-INCH STROKE.

passage wall only. A little graphite and oil applied when the guide is put in prevent rusting at this point. The portion of the guide entering the cylinder wall is not threaded and is a comparatively free fit, tightness being secured by screwing the guide down on a thin corrugated copper gasket under the shoulder. The inside of the guide near the bottom is of hexagonal shape, to be engaged by a special wrench furnished for removing and replacing the guide. The cap, which firmly locks the guide, has a hexagonal projection which fits the same wrench. On the high pressure cylinder of two-stage machines a copper gasket is also placed under the cap, so that the fit in the cylinder is not depended upon for tightness, and the guide can be removed in a fraction of the time ordinarily required.

The discharge valve guide screws into the discharge passage wall and rests on a corrugated copper gasket on the cylinder wall. The seat is contained with the guide, avoiding wear on the cylinder, and the seat being removable is readily inspected and the valve may be ground in without danger of emery entering the cylinder. This is a great improvement over allowing the valve to seat on the cylinder wall, or screwing a separate seat into the cylinder wall. Such a seat persists in working loose under the constant hammering of the valve, and if not noticed at once the thread is destroyed on the seat and sometimes in the cylinder. By a simple device the discharge valves are rendered quiet running and very positive in operation.

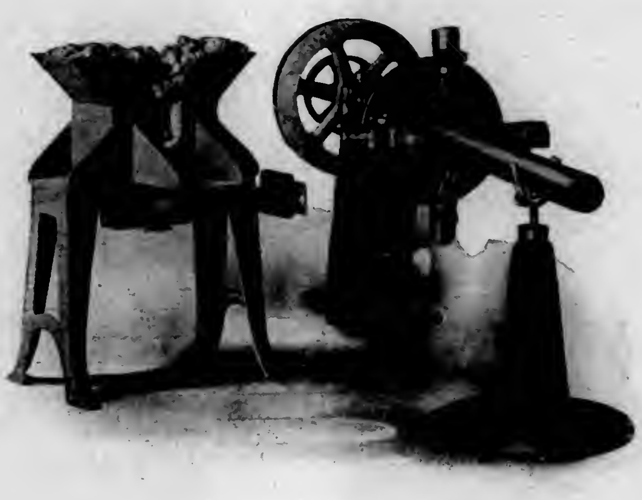
The positive inlet valves, furnished on special order only, are placed in the cylinder barrel instead of in the heads, as is usual with this type. The heads are thus entirely free from mechanism, have full cooling area, and being much lighter than the usual form are easily removed by one man. Lubrication is effected by high grade sight feed devices or by force feed or gravity system, as desired. Duplex machines, as shown in Fig. 1, have been shipped to the Pennsylvania Railroad Company, Frick Coke Company, Oak Park Power Company, etc.

RYERSON FLUE WELDING MACHINE.

It is now generally conceded that the most satisfactory and rapid flue welding can be done on the roller type of machine and the greatest development has been in this type. One of the latest designs of this kind, evolved after a careful study of the requirements of the service, is being built by Joseph T. Ryerson and Son, of Chicago, and is shown in the accompanying illustration.

This machine consists of a very substantial base on which a shaft is mounted in suitable bearings. This shaft carries a driving pulley, or gear wheel if electrically driven—and a flywheel at one end and an internal roller carrying mandrel at the other. This mandrel closely resembles the ordinary type of flue expander and is designed to roll the inside of the tube during the welding process. Mandrels of different sizes are provided with the machine and are interchangeable by simply screwing the threaded end into the driving shaft. This end of the shaft also carries a steel head, which is provided with arms for carrying large rollers for rolling down the outside of the tube during welding. These outside rollers are disposed directly opposite the inside rollers and are adjustable for any thickness of tube. They are brought down toward the mandrel by means of a foot treadle, which will be noticed in the illustration. The construction is such that these outside rollers cannot approach the mandrel rollers any closer than the thickness of the tube wall for which they are adjusted.

It will be seen that this machine possesses a number of important features providing for very rapid and accurate work and in addition, because of the absence of any air or steam connections, it is more or less of a portable type. The construction of the adjusting device is such that it requires no skill on the part of the operator, but is still so accurate as to provide for adjustments of 1/100 of an inch. For performing this operation



RYERSON FLUE WELDING MACHINE.

a cold tube is placed on the mandrel, the arms of the machine are brought down and the rollers simply set to touch the tube and then tightened in place. There are no gears required and the machine is practically noiseless in operation.

AIR COMPRESSORS FOR THE RAILWAY SHOP.

By H. Edsil Barr.

The rapid modernization of the railway shops, in equipment and methods, has included the increased use of compressed air for many purposes. The compressor plant has become of vital importance and there is a demand for a high grade, rugged, and thoroughly substantial compressor equipment capable of giving constant, economical service at high pressure and increased speed compared with the light and uneconomical machine commonly in use a decade past. The machines illustrated herewith have been recently added to the line of air compressors built by the Bury Compressor Company, Erie, Pa., and are specially adapted for railway shop service.

The massiveness and rigidity of these machines are apparent. The frames are of the bored guide type, with heavy duty quarter box bearings, which are tied into the frame body by heavily ribbed, long sweep housings. The air and steam cylinders are held rigidly in line by the circular, internally flanged yoke, which is provided with large side holes for conveniently reaching the stuffing boxes. The machine proper—frame and cylinders, with attached parts—is secured by through and tap bolts to an unusually deep sub base, which on the two stage machines includes the intercooler, making the entire outfit self contained, of perfect alignment and adapted to run as satisfactorily on a good timber cribbing as on a more permanent foundation of concrete or brick.

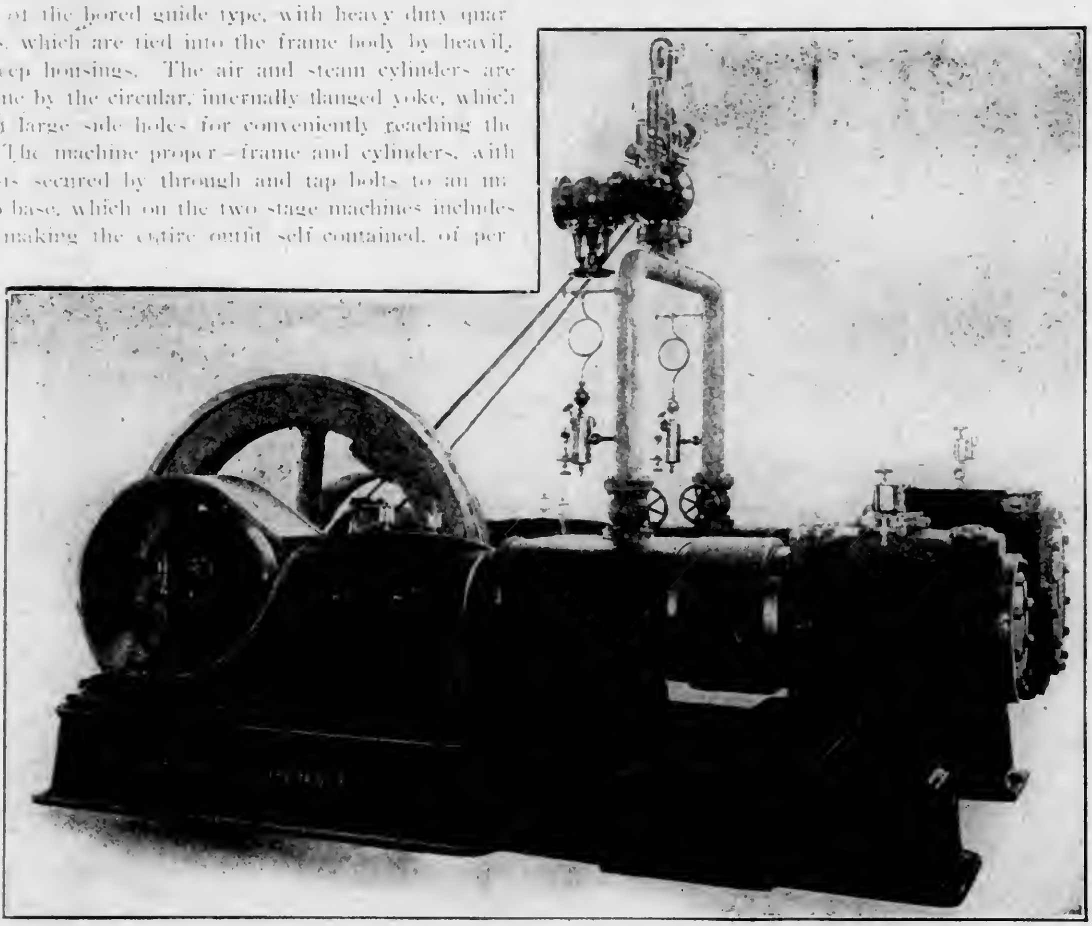


FIG. 1.—DUPLEX BURY COMPRESSOR—BUILT WITH SIMPLE OR TWO-STAGE AIR AND SIMPLE OR COMPOUND STEAM CYLINDERS.

The crank shafts and connecting rods are of forged open hearth steel. The crank of the duplex machines is of the built up type, with balanced disks forced on the shaft and held by two keys. The pin is forced in and riveted. The various operations in the building up of this crank are done with a care and precision which makes the completed crank practically as solid and true as if made from one piece. The single crank shaft is slotted from a single forging, the pin and journals are turned with large fillets, and the shaft is fitted with counterweighted disks mounted on the wings of the crank by a special construction, the joints being all machined and no babbitt or other soft metal likely to loosen from shrinkage being used.

The connecting rods have the approved marine crank end and solid crosshead end. The crank end boxes are lined with babbitt and the crosshead boxes are phosphor bronze. All babbitt in the main bearings and connecting rods is poured into dovetailed recesses, after which it is peened thoroughly to overcome shrinkage and the box is bored to fit the pin or journal. The crosshead is of box form, with adjustable shoes and steel wrist pin drawn in on a continuous taper and securely fastened. The careful construction of all bearings and the methods used to insure perfect alignment make these machines remarkably smooth in operation with small friction loss.

The steam valve is a balanced, double ported slide type, having very short steam ports, and is well suited to the operation of compressor or engine, giving economical service with little attention aside from lubrication. The steam cylinders are lagged with asbestos to reduce radiation, and are covered with a heavy polished blue steel jacket. The cranks of the duplex machine are protected by a polished steel guard with heavy angle iron piece, and the single crank machine may also be so fitted.

The air valves, the vital parts of any compressor, as ordinarily furnished, are of the automatic, direct lift type, with spring closure, operating in guides of a recently improved form, which possess features worthy of special attention. The most common form of inlet valve guide is made of brass and screwed into the wall of the cylinder or head. This thread is straight, and, being depended upon to a great extent for tightness, is made a good fit in the tapped hole. The guide is made of brass to prevent its corroding to the cylinder metal in the thread, as it would if it was of iron, but as fully an annoying trouble is experienced by the cylinder oil working in around the thread and becoming carbonized from the heat of compression to an extent which makes it extremely difficult to remove the guide. In some cases which have come under the writer's notice it has been necessary to chip the guide out. Some, knowing the possibility of this trouble, have resorted to removing the guides once a week and cleaning with gasoline. This is effective, but the softer thread of the brass soon wears loose from frequent removal, and few operators will go to this trouble. In fact, often the opportunity is not available.

It becomes advisable, therefore, to avoid the necessity of such attention, and the guide adopted accomplishes the purpose admirably. The guide and seat are one piece, an iron casting, which screws into the metal of the cylinder in the cool air

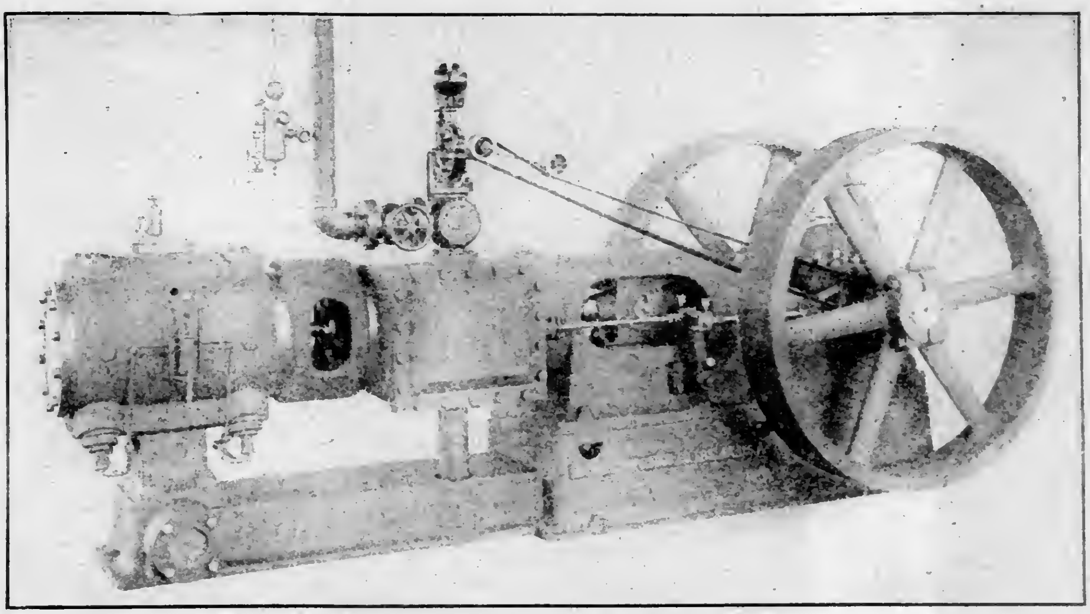


FIG. 2.—CLASS B. S. BURY COMPRESSOR—1., 14 AND 10-INCH STROKE.

ssage wall only. A little graphite and oil applied when the uide is put in prevent rusting at this point. The portion of the uide entering the cylinder wall is not threaded and is a comparatively free fit, tightness being secured by screwing the guide own on a thin corrugated copper gasket under the shoulder. e inside of the guide near the bottom is of hexagonal shape, be engaged by a special wrench furnished for removing and placing the guide. The cap, which firmly locks the guide, has hexagonal projection which fits the same wrench. On the high essure cylinder of two-stage machines a copper gasket is also aced under the cap, so that the fit in the cylinder is not depended upon for tightness, and the guide can be removed in a action of the time ordinarily required.

The discharge valve guide screws into the discharge passage all and rests on a corrugated copper gasket on the cylinder all. The seat is contained with the guide, avoiding wear on the linder, and the seat being removable is readily inspected and the valve may be ground in without danger of emery entering the cylinder. This is a great improvement over allowing the valve to seat on the cylinder wall, or screwing a separate seat into the cylinder wall. Such a seat persists in working loose under the constant hammering of the valve, and if not noticed at once the thread is destroyed on the seat and sometimes in the cylinder. By a simple device the discharge valves are rendered quiet running and very positive in operation.

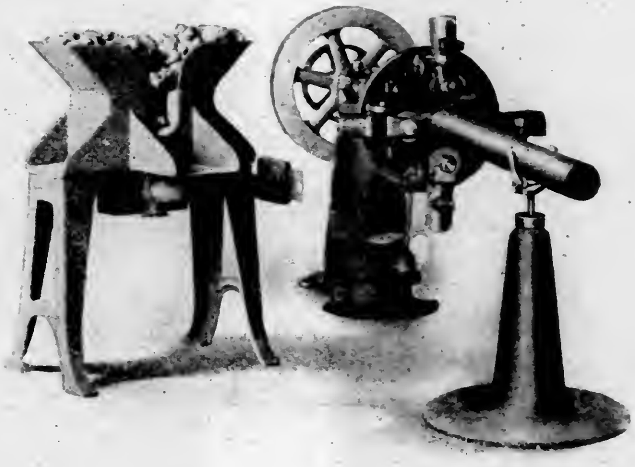
The positive inlet valves, furnished on special order only, are placed in the cylinder barrel instead of in the heads, as is usual with this type. The heads are thus entirely free from mechanism, have full cooling area, and being much lighter than the usual form are easily removed by one man. Lubrication is effected by high grade sight feed devices or by force feed or gravity system, as desired. Duplex machines, as shown in Fig. 1, have been shipped to the Pennsylvania Railroad Company, Frick Coke Company, Oak Park Power Company, etc.

RYERSON FLUE WELDING MACHINE.

It is now generally conceded that the most satisfactory and rapid flue welding can be done on the roller type of machine nd the greatest development has been in this type. One of the test designs of this kind, evolved after a careful study of the quirements of the service, is being built by Joseph T. Ryeron and Son, of Chicago, and is shown in the accompanying illustration.

This machine consists of a very substantial base on which a aft is mounted in suitable bearings. This shaft carries a drivg pulley, or gear wheel if electrically driven—and a flywheel one end and an internal roller carrying mandrel at the other. his mandrel closely resembles the ordinary type of flue exnder and is designed to roll the inside of the tube during the elding process. Mandrels of different sizes are provided with e machine and are interchangeable by simply screwing the readed end into the driving shaft. This end of the shaft also rries a steel head, which is provided with arms for carrying rge rollers for rolling down the outside of the tube during elding. These outside rollers are disposed directly opposite e inside rollers and are adjustable for any thickness of tube. hey are brought down toward the mandrel by means of a foot edle, which will be noticed in the illustration. The construcon is such that these outside rollers cannot approach the manrel rollers any closer than the thickness of the tube wall for hich they are adjusted.

It will be seen that this machine possesses a number of important features providing for very rapid and accurate work nd in addition, because of the absence of any air or steam connections, it is more or less of a portable type. The construction of the adjusting device is such that it requires no skill on the part of the operator, but is still so accurate as to provide for adjustments of 1/100 of an inch. For performing this operation



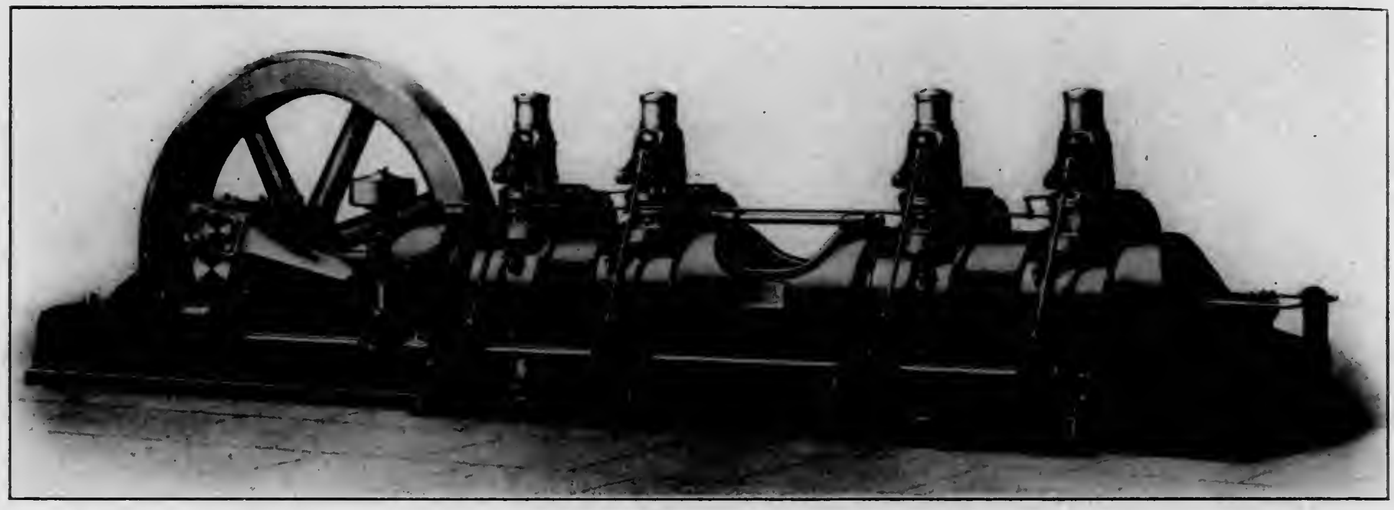
RYERSON FLUE WELDING MACHINE.

a cold tube is placed on the mandrel, the arms of the machine are brought down and the rollers simply set to touch the tube and then tightened in place. There are no gears required and the machine is practically noiseless in operation.

Provision is also made for attachments which will permit scarfing, spreading or cutting off tubes. This is accomplished by simply removing the roll mandrel and substituting the proper scarfing rolls, spreading devices, or cutting wheels. Such a change can be made in a very few minutes.

The address of Joseph T. Ryerson & Son is Commercial National Bank Building, Chicago, Ill.

without in any way affecting the engine alignment. The valve gear has been simplified and its reliability increased by doing away with the spiral gear drive for the lay shaft and by operating both the inlet and exhaust valves from a single eccentric. All parts subject to wear are fitted with adjustable devices for taking up the wear and the aim has been to produce an engine well suited to the demands of a 24-hour service.



600 H.P., MESTA GAS ENGINE.

THE MESTA GAS ENGINE.

Modern heavy duty gas engines have now reached a stage where they occupy a recognized and important position in the power field. These machines in large sizes are much more similar to heavy duty steam engines than are small gas engines and hence it is not so much of a departure for a successful manufacturer of heavy duty Corliss and piston valve reversing steam engines taking up the manufacture of large gas engines as it would be in smaller sizes. The Mesta Machine Company of Pittsburg, Pa., which has recently made such a move, is in a specially fortunate position for manufacturing successful gas engines, since, from its long experience in the heavy duty steam engine field, it has an accurate knowledge of the requirements of such machines and is possessed of a fully equipped plant capable of providing the best of materials and machine work. The plant of this company has air furnaces for supplying iron of the high tensile strength and superior wearing qualities so necessary in cylinder construction; open hearth furnaces for steel castings, containing nickel or vanadium as may be desired and a complete brass foundry.

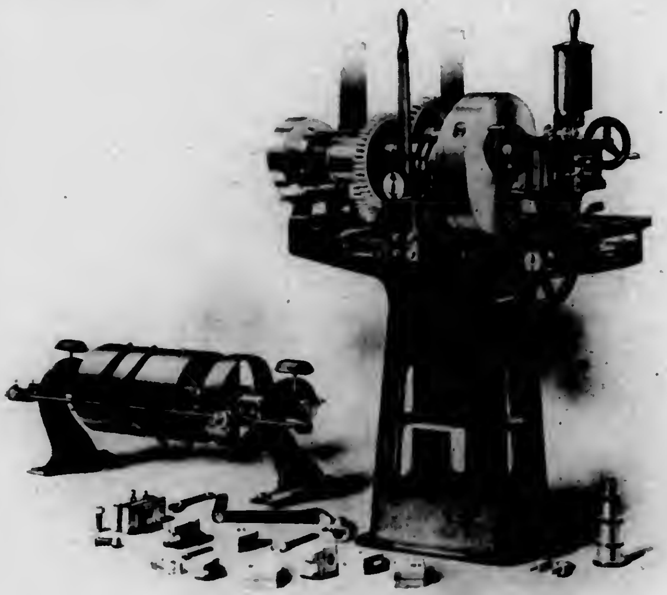
The accompanying illustration shows the general arrangement of a 600 h.p., 400 k.w. direct connected unit now in process of construction in the works at West Homestead, which typifies a series of sizes called for in the designs as at present decided upon. This engine, it is believed, embodies the best features of both European and American practice and in addition has many improvements which tend toward more economical and successful operation under the exacting conditions of the widely fluctuating loads which are so frequently met with in American practice. Very careful attention has also been given to the development of a design suitable for use with producer, blast or other by-product gases.

These engines are designed to operate on the four-cycle principle and are built in either tandem or twin tandem arrangement. The placing of two double acting cylinders in tandem results in two power strokes per revolution, giving very close regulation and making it perfectly feasible to operate 60-cycle generators in parallel without using any form of flexible coupling. When the twin tandem type is employed the power strokes are doubled and the same effective torque is obtained as in the cross compound steam engine. Very careful attention has been given to the matter of longitudinal expansion and the cylinders are permitted to expand or contract with the varying temperature

For the development of this line of engines, ranging in capacity from 500 to 5,000 h.p., this company has secured the services of Frederick Ottesen, who has had a wide European and American experience in gas engine design and has spent over a year in the development of the design illustrated.

PIPE THREADING AND CUTTING-OFF MACHINE.

The Crane Company, Chicago, has placed an inexpensive, but high grade, pipe threading and cutting-off machine on the market, which may be operated either by hand or power. It is known



CRANE PIPE THREADING AND CUTTING-OFF MACHINE.

as No. 1¼, has a capacity for ⅛ to 2-inch pipe and is simple in construction, adjustment and operation. The frame or bed, a single casting, is of light but rigid construction and occupies a minimum amount of floor space.

The die head is bolted to a movable carriage. The dies are of an improved adjustable type, made collapsible, and are simi-

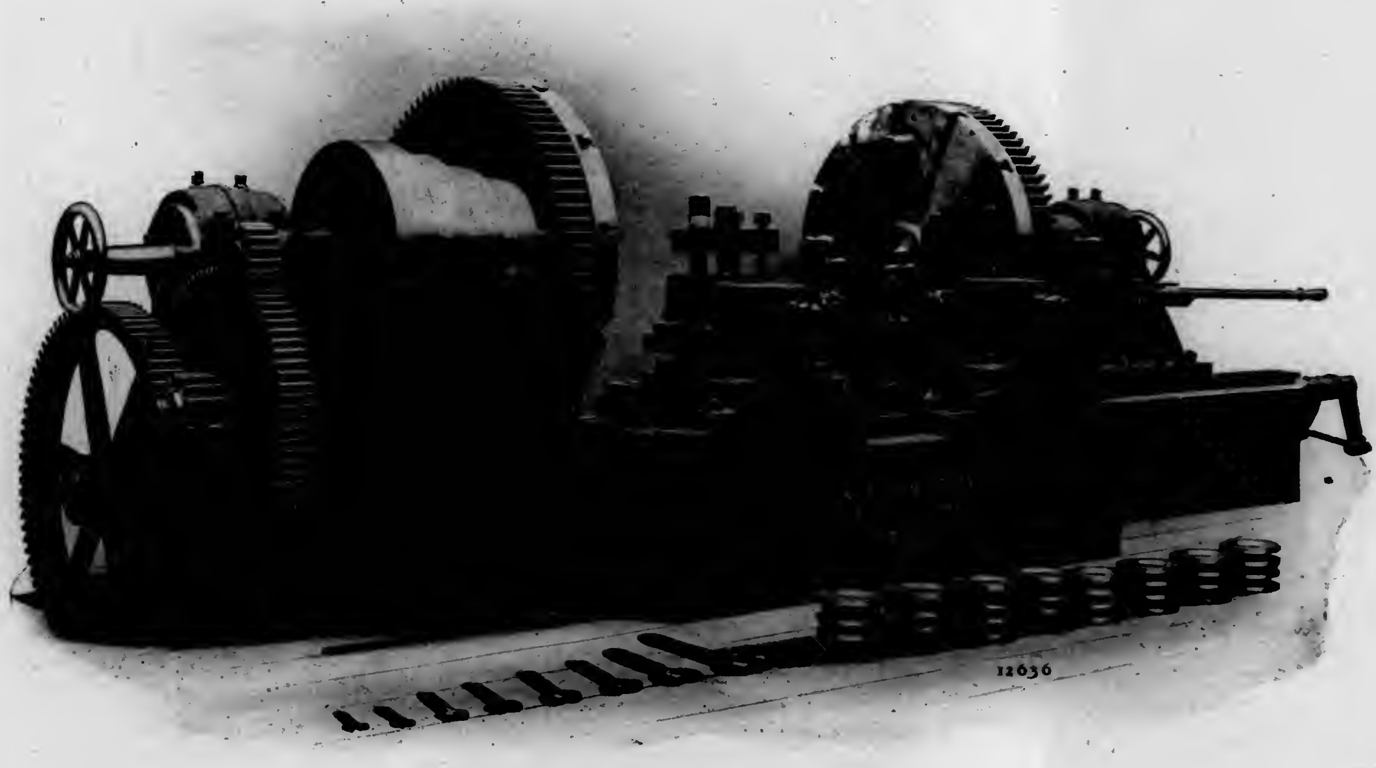
lar to those supplied with the Crane hand die stocks. The frames which carry the dies slide in guides and are moved by a screw, operated by a hand wheel. The dies are set to gauge by a simple locking device, thus allowing any number of pieces of pipe of the same size to be threaded without further adjustment. The dies have four cutting edges and will give good service on either wrought iron or steel pipe. They are made interchangeable and one die of a set may be replaced if broken. When not in use on the machine the dies may be used in a hand stock. A set of dies may be changed on the machine in a few seconds.

When cutting off, the pipe is guided by two steel guides hardened on the face. These guides are operated by a right and left screw and hand wheel. The cutting-off tool is operated by a lever and rack. The gripping chuck is rapid in action and is very powerful. The pipe may be released and gripped by moving a lever without stopping the machine. The chuck is adjustable for different sizes of pipe, within range of the machine, without moving or altering the jaws. The jaws are of tool steel and are removable for grinding or replacing.

The rear end of the spindle is fitted with a universal centering chuck, compact in design and readily adjustable to the various sizes of pipe. Oil is supplied from a small tank on a swivel joint above the die head. Another tank is placed in the frame to which the oil from the dies is drained. Three changes of speed are obtained by gears which are shifted by a lever conveniently placed. The machine may be driven from a countershaft or it may be operated by hand, the necessary crank for this purpose being furnished with each machine. Bolt dies, 1/4 to 1 1/2 in., may be furnished if desired. The machine weighs 700 lbs. and requires a floor space of 44 x 23 in.

STEEL-TIRED CAR-WHEEL LATHE.

The Niles car-wheel lathe, shown in the illustration, is designed for turning steel-tired car wheels up to 42 inches diameter on the tread, and is arranged to take axles having either inside or outside journals. To turn wheels on axles having outside journals, the centers are removed and the axles are chucked by collapsing bushings of suitable size, which fit into taper sleeves within the spindles. The wheels are brought close to the face plates and are gripped securely by the patent "sure-grip" drivers, which engage the tires near the rim and hold the wheels absolutely rigid with the face plates.



NILES STEEL-TIRED CAR-WHEEL LATHE.

To turn wheels on axles having inside journals the ordinary centers are used and the wheels are gripped by the drivers in the usual manner. The face plates are mounted on spindles of extra large diameter. The right-hand head is movable on the bed by rack and pinion operated by lever.

The tool rests have swiveling bases adjustable in and out on the carriages and are provided with power longitudinal feed driven by ratchets with positive connections, which are operated from the rocker shaft at the front. The carriages have adjustment parallel to the length of the bed for varying gauges. The tool posts are fitted with an improved type of tool clamp, enabling the tools to be set with the greatest facility and in the shortest possible time. To prevent chips, falling between the face plates, from getting into the working parts of the machine, a sheet-iron telescoping cover is provided extending from one face plate to the other.

A calipering attachment is supplied (not shown in the illustration), consisting of a cross-bar extending above and across the face plates and set parallel with the center line of the machine. With this is furnished a suitable measuring device for determining the relative diameter of the two wheels. A four-step cone is used with the belt drive, or the machine can be arranged for motor drive—preferably by a motor of the variable speed type.

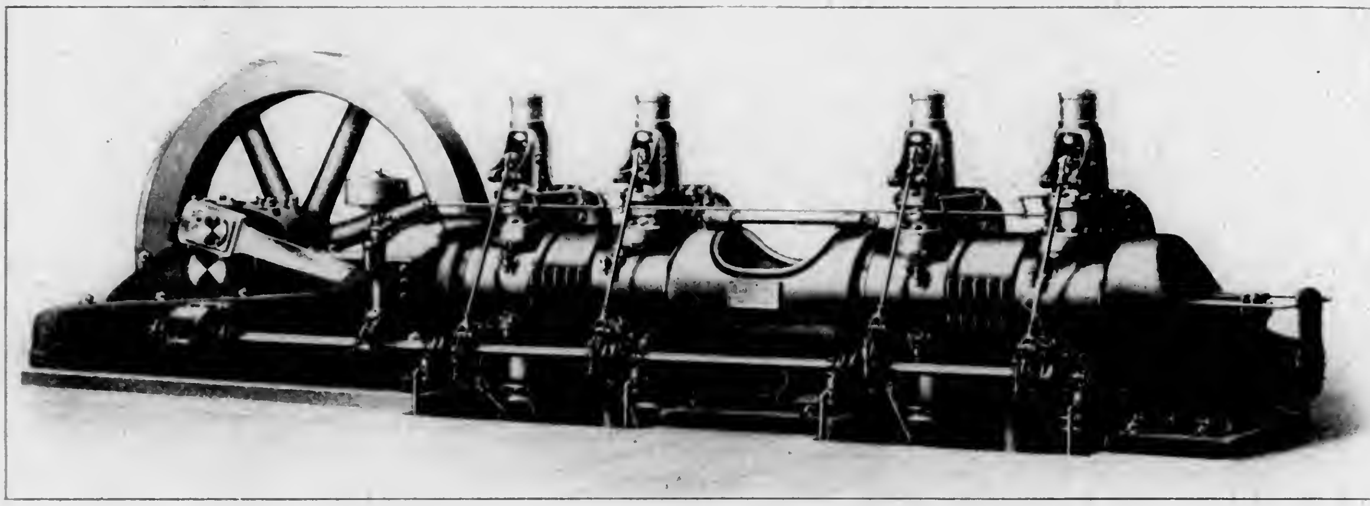
For railroad work the machine is provided with four sets of axle bushings for 3 3/4, 4 1/4, 5 and 5 1/2 in. standard M. C. B. axles. For traction wheels, bushings suitable to diameters of the axle journals are provided.

FUEL ECONOMY.—If American locomotives were of a more highly developed type such as are much employed for foreign service, if they were designed with compound cylinders or with superheaters, the amount of fuel required would be less and the annual coal consumption would be reduced 6,000,000 to 10,000,000 tons.—*Dr. W. F. M. Goss before A. S. M. E.*

Provision is also made for attachments which will permit scarfing, spreading or cutting off tubes. This is accomplished by simply removing the roll mandrel and substituting the proper scarfing rolls, spreading devices, or cutting wheels. Such a change can be made in a very few minutes.

The address of Joseph T. Ryerson & Son is Commercial National Bank Building, Chicago, Ill.

without in any way affecting the engine alignment. The valve g has been simplified and its reliability increased by doing aw with the spiral gear drive for the lay shaft and by operating b the inlet and exhaust valves from a single eccentric. All pa subject to wear are fitted with adjustable devices for taking the wear and the aim has been to produce an engine well sui to the demands of a 24 hour service.



600 H.P., MESTA GAS ENGINE.

THE MESTA GAS ENGINE.

Modern heavy duty gas engines have now reached a stage where they occupy a recognized and important position in the power field. These machines in large sizes are much more similar to heavy duty steam engines than are small gas engines and hence it is not so much of a departure for a successful manufacturer of heavy duty Corliss and piston valve reversing steam engines taking up the manufacture of large gas engines as it would be in smaller sizes. The Mesta Machine Company of Pittsburg, Pa., which has recently made such a move, is in a specially fortunate position for manufacturing successful gas engines, since, from its long experience in the heavy duty steam engine field, it has an accurate knowledge of the requirements of such machines and is possessed of a fully equipped plant capable of providing the best of materials and machine work. The plant of this company has air furnaces for supplying iron of the high tensile strength and superior wearing qualities so necessary in cylinder construction; open hearth furnaces for steel castings, containing nickel or vanadium as may be desired and a complete brass foundry.

The accompanying illustration shows the general arrangement of a 600 h.p., 400 k.w. direct connected unit now in process of construction in the works at West Homestead, which typifies a series of sizes called for in the designs as at present decided upon. This engine, it is believed, embodies the best features of both European and American practice and in addition has many improvements which tend toward more economical and successful operation under the exacting conditions of the widely fluctuating loads which are so frequently met with in American practice. Very careful attention has also been given to the development of a design suitable for use with producer, blast or other by-product gases.

These engines are designed to operate on the four-cycle principle and are built in either tandem or twin tandem arrangement. The placing of two double acting cylinders in tandem results in two power strokes per revolution, giving very close regulation and making it perfectly feasible to operate 60-cycle generators in parallel without using any form of flexible coupling. When the twin tandem type is employed the power strokes are doubled and the same effective torque is obtained as in the cross compound steam engine. Very careful attention has been given to the matter of longitudinal expansion and the cylinders are permitted to expand or contract with the varying temperature

For the development of this line of engines, ranging in capaci from 500 to 5,000 h.p., this company has secured the servic of Frederick Ottesen, who has had a wide European and Amer ican experience in gas engine design and has spent over a ye in the development of the design illustrated.

PIPE THREADING AND CUTTING-OFF MACHINE.

The Crane Company, Chicago, has placed an inexpensive, bu high grade, pipe threading and cutting off machine on the mar ket, which may be operated either by hand or power. It is know

CRANE PIPE THREADING AND CUTTING-OFF MACHINE.

as No. $1\frac{1}{4}$, has a capacity for $\frac{1}{8}$ to 2-inch pipe and is simple in construction, adjustment and operation. The frame or bed, a single casting, is of light but rigid construction and occupies a minimum amount of floor space.

The die head is bolted to a movable carriage. The dies are of an improved adjustable type, made collapsible, and are simi

ar to those supplied with the Crane hand die stocks. The frames which carry the dies slide in guides and are moved by a screw, operated by a hand wheel. The dies are set to gauge by a simple locking device, thus allowing any number of pieces of pipe of the same size to be threaded without further adjustment. The dies have four cutting edges and will give good service on either wrought iron or steel pipe. They are made interchangeable and one die of a set may be replaced if broken. When not in use on the machine the dies may be used in a hand stock. A set of dies may be changed on the machine in a few seconds.

When cutting off, the pipe is guided by two steel guides hardened on the face. These guides are operated by a right and left screw and hand wheel. The cutting off tool is operated by a lever and rack. The gripping chuck is rapid in action and is very powerful. The pipe may be released and gripped by moving a lever without stopping the machine. The chuck is adjustable for different sizes of pipe, within range of the machine, without moving or altering the jaws. The jaws are of tool steel and are removable for grinding or replacing.

The rear end of the spindle is fitted with a universal centering chuck, compact in design and readily adjustable to the various sizes of pipe. Oil is supplied from a small tank on a swivel joint above the die head. Another tank is placed in the frame to which the oil from the dies is drained. Three changes of speed are obtained by gears which are shifted by a lever conveniently placed. The machine may be driven from a countershaft or it may be operated by hand, the necessary crank for this purpose being furnished with each machine. Bolt dies, $\frac{1}{4}$ to $1\frac{1}{4}$ in., may be furnished if desired. The machine weighs 700 lbs. and requires a floor space of 44 x 23 in.

STEEL-TIRED CAR-WHEEL LATHE.

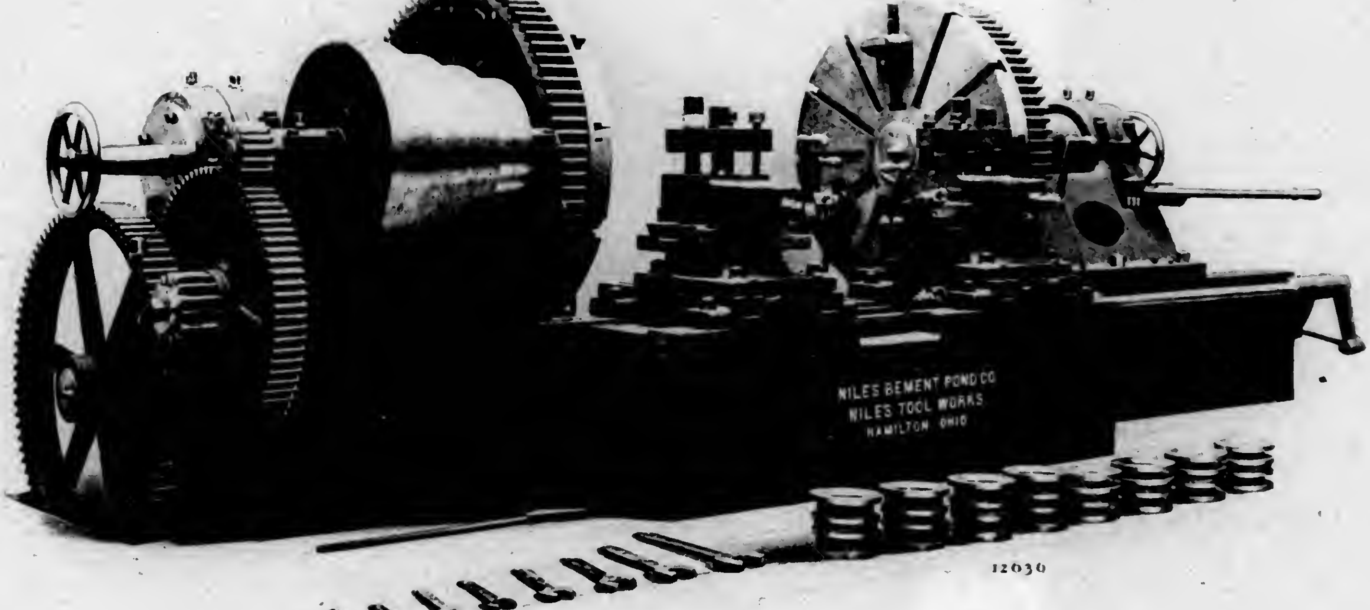
The Niles car wheel lathe, shown in the illustration, is designed for turning steel tired car wheels up to 42 inches diameter on the tread, and is arranged to take axles having either inside or outside journals. To turn wheels on axles having outside journals, the centers are removed and the axles are chucked by collapsing bushings of suitable size, which fit into taper sleeves within the spindles. The wheels are brought close to the face plates and are gripped securely by the patent "sure grip" drivers, which engage the tires near the rim and hold the wheels absolutely rigid with the face plates.

To turn wheels on axles having inside journals the ordinary centers are used and the wheels are gripped by the drivers in the usual manner. The face plates are mounted on spindles of extra large diameter. The right-hand head is movable on the bed by rack and pinion operated by lever.

The tool rests have swiveling bases adjustable in and out on the carriages and are provided with power longitudinal feed driven by ratchets with positive connections, which are operated from the rocker shaft at the front. The carriages have adjustment parallel to the length of the bed for varying gauges. The tool posts are fitted with an improved type of tool clamp, enabling the tools to be set with the greatest facility and in the shortest possible time. To prevent chips, falling between the face plates, from getting into the working parts of the machine, a sheet iron telescoping cover is provided extending from one face plate to the other.

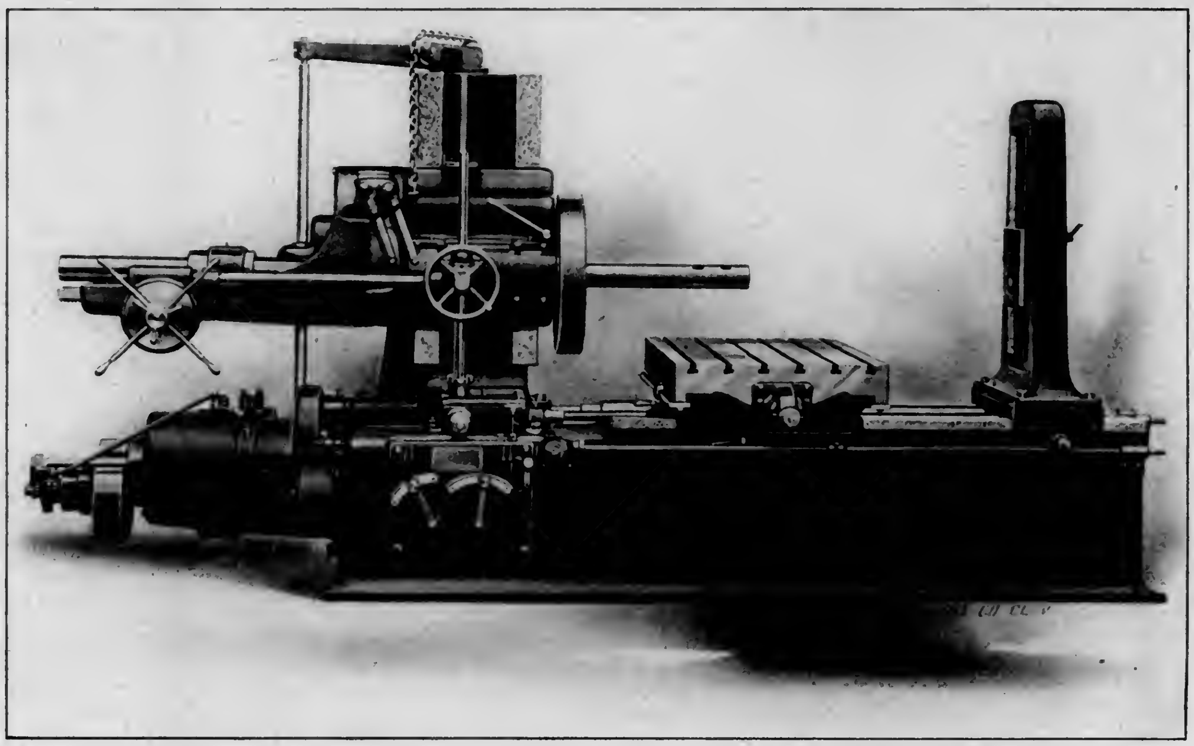
A calipering attachment is supplied (not shown in the illustration), consisting of a cross bar extending above and across the face plates and set parallel with the center line of the machine. With this is furnished a suitable measuring device for determining the relative diameter of the two wheels. A four-step cone is used with the belt drive, or the machine can be arranged for motor drive, preferably by a motor of the variable speed type.

For railroad work the machine is provided with four sets of axle bushings for $3\frac{3}{4}$, $4\frac{1}{4}$, 5 and $5\frac{1}{2}$ in. standard M. C. B. axles. For traction wheels, bushings suitable to diameters of the axle journals are provided.



NILES STEEL-TIRED CAR-WHEEL LATHE.

FUEL ECONOMY.—If American locomotives were of a more highly developed type such as are much employed for foreign service, if they were designed with compound cylinders or with superheaters, the amount of fuel required would be less and the annual coal consumption would be reduced 6,000,000 to 10,000,000 tons.—*Dr. W. F. M. Goss before A. S. M. E.*



LUCAS HORIZONTAL BORING, DRILLING AND MILLING MACHINE.

HORIZONTAL BORING, DRILLING AND MILLING MACHINE.

The No. 3 "Precision" horizontal boring, drilling and milling machine shown in the illustration is giving splendid results in the railroad shops in which it is being used, because of its accuracy and adaptability to a wide range of work. Special attention has been given to the design and construction of this type of machine to make it as useful for tool room work, requiring great accuracy, as for general manufacture, where power and rigidity are the principal essentials. To illustrate its adaptability two examples may be taken from railroad shop practice; the holes may be bored in a tumbling shaft and the hubs faced parallel, and true with the holes, by milling at one setting; air pump cylinders may be bored and both ends faced by milling at one setting.

It will be seen that instead of raising and lowering the platen with its load, the weight of which is widely variable, the spindle head, which is a constant weight, is raised and lowered. This construction allows the use of a deep box bed of great stiffness, which gives a solid foundation to the other members of the machine and keeps them in accurate relation to each other in all positions; for this reason the machine does not require a special foundation and its location is not confined to the ground floor. Not only can work be bored, drilled and milled at one setting, but because of the "Precision" screws, with graduated dials, the work can be done accurately, without any measuring or any of the usual necessary preliminaries. A large amount of extra handling and setting is therefore eliminated, greatly increasing the capacity of the machine. This construction also allows the addition of the vertical power feed for milling purposes, which is a very valuable feature for many classes of work.

The spindle is of unannealed hammered crucible steel, is accurately ground its entire length and has a long bearing in the sleeve. It is forged and turned at least six months before it is finished and is allowed to "season" between every operation in its manufacture. The front of the driving gear forms a face plate to which the facing head, face milling cutters, or other large tools may be attached. Milling feeds to the platen and head (which includes the outer support for the boring bar) make the machine universal and capable of finishing at one setting many pieces which would otherwise require resetting and finishing in other machines. The addition of a graduated revolving table makes it possible to bore and drill holes and to mill surfaces at various angles.

The power cross feed to the platen, of good length, makes the machine complete for milling purposes, thus increasing its usefulness and making it possible to produce work which requires this feature at a lower cost, due to the elimination of rehandling and resetting; it also makes it possible to keep the machine running where it might otherwise have to lay idle, thus increasing its earning capacity. The length of the cross feed to the platen is great enough so that in many cases a job may be made ready at one end while the machine is boring another piece at the other end.

The yoke is adjusted along the bed with a wrench, and since there is a geared connection between the two screws that adjust the spindle head and the outer support for the boring bar, which is in the yoke, the outer support is kept in alignment with the spindle and cannot be thrown out by chips getting under the yoke, since it is fitted to the bed. The yoke may be entirely removed and then be put back in its original position without disturbing the alignment of the outer support for the boring bar with the spindle. This is a valuable feature where it is necessary to do work on pieces which are longer than the normal capacity of the machine. The outer support for the boring bar is bored after the machine is assembled, thus insuring its perfect alignment with the spindle.

The driving gears in the speed box are made of steel and are controlled by two levers giving nine changes of speed. Two levers on the head of the machine, which are interlocked, multiply this by two, making a total of eighteen changes of speed in geometrical progression. At each spindle speed only such gears as are in mesh as are used to obtain that speed and there is, therefore, no frictional loss due to the revolving of idle gears. The driving pulley runs on a stationary bushing and the belt pull does not come on the driving shaft. The main driving clutch is operated by a lever at the front of the machine within easy reach of the operator; when the machine is stopped only the driving pulley continues in motion. A direct connected motor drive may be applied if desired.

The feed motion is taken from one of the driving shafts, which runs at a higher speed than the spindle This makes it possible to obtain the coarse feeds without gearing up, thus avoiding excessive strain on the feed gears and bearings and allowing the feed train to do its work easily. The fine feeds are

obtained by gearing down. Another advantage of this arrangement is that it gives two series of feeds, a coarse series with the back gears *in* and a fine series with the back gears *out*. There are 18 variations of feed, nine for either position of the spindle back gears, from .005 to .537 in. per revolution of the spindle. The rate of feed is the same for every part to which it is applied. The machine is regularly supplied with automatic feed to the spindle, automatic cross feed and vertical feed to the head. The head and outer support for the boring bar may be quickly moved by power and may also be moved by hand from both the front and end of the machine.

The adjustments of the spindle head, the outer support for the boring bar and the platen are made by "Precision" screws. These are provided with dials graduated to read to thousandths of an inch, thus allowing holes to be bored or drilled, and surfaces to be milled, at an exact distance apart, making it possible to easily produce interchangeable work without the use of jigs, or jigs may be originated on the machine more quickly and accurately than by any other method.

The platen is of extra size and thickness and has finished T slots. It will be seen that it is especially deep, the aim being to make it so stiff that with ordinary care there will be no appreciable springing when the work is clamped upon it.

The machine illustrated is at present the largest of the various sizes which are made by the Lucas Machine Tool Company of Cleveland, O. It has a spindle 4 in. in diameter with 60 in. total traverse. The greatest distance between the face plate and the outer support for the boring bar is 6 ft. The greatest distance from the top of the platen to the center of the spindle is 26 in. The platen, which is 30 in. wide and 48 in. long, has a cross feed of 36 in.

2-FOOT BACK GEARED, HIGH SPEED, RADIAL DRILL.

The 2-ft. back geared, high speed, radial drill, illustrated herewith, has been designed by the American Tool Works Company of Cincinnati to meet the demand as a substitute for the larger sizes of upright drills, over which it has many advantages. That this machine is well adapted for the most severe service may be seen from the accompanying tables giving the results of a number of tests which have been made on it.

It drills to the center of a 4 ft. 5 in. circle, outside of the column. The greatest distance from the spindle to the base is 3 ft. 9-1-½ in.; the spindle has a traverse of 11 in. and the head has a traverse of 16 in. on the arm. The column is of the double tubular type and is exceptionally rigid. The sleeve or outer column revolves on conical roller bearings, hardened and ground, and is clamped in any position by a patent V clamping ring, which may be moved around the column to suit the convenience of the operator. This makes the outer column practically integral with the inner one, which extends almost the entire height and has full bearings for the outer column at both top and bottom.

The arm is of parabolic beam and tube section, making it very strong for resisting bending and torsional strains. The lower edge is parallel with the base, thus permitting work to be operated upon close to the column without the necessity for an extreme reach of the spindle. The arm is clamped to the column by two binder levers and is provided with a gib screw permitting the arm to work freely, without sagging, while the binder handles are loose. It is raised and lowered rapidly by a double thread coarse pitch screw, which may be controlled instantly by a convenient lever, arrow points indicating the proper direction. The head may be moved rapidly along the arm by a hand wheel which operates an angular rack and spiral rack pinion. It may be locked in any position. The back gears are located on the head, thus bringing the greatest speed reduction direct to the spindle; it may be engaged or disengaged while the machine is in operation.

The speed box is of the geared friction type, is very powerful and provides four changes of speed, any one of which may be instantly obtained by the two levers. This in combination

DRILLING TEST IN CAST IRON 2" THICK.

Size Drill	Speeds		Feeds		Back Gears		Actual H.P.	Amp.	Volts
	Revol's	Cutting Speed	Per Revol'n	Ins. Per Min.	Ratio	Positn.			
¾" H.S.	290	56.9	.015"	4.35	1.5	Top	3.68	9	230
¾" H.S.	406	79.7	.020"	8.12	1.5	"	7.40	20	"
1 3/32" H.S.	290	83.	.020"	5.8	1.5	"	7.40	20	"
1 3/32" H.S.	406	116.2	.020"	8.12	1.5	"	11.1	32	"
1 15/32" H.S.	290	111.4	.015"	4.35	1.5	"	10.5	30	"
1 15/32" H.S.	290	111.4	.020"	5.8	1.5	"	13.5	40	"
1 29/32" H.S.	207	79.5	.007"	1.4	1.5	"	6.5	17	"
1 29/32" H.S.	207	79.5	.020"	4.14	1.5	"	13.5	40	"

DRILLING TEST IN STEEL 3" THICK.

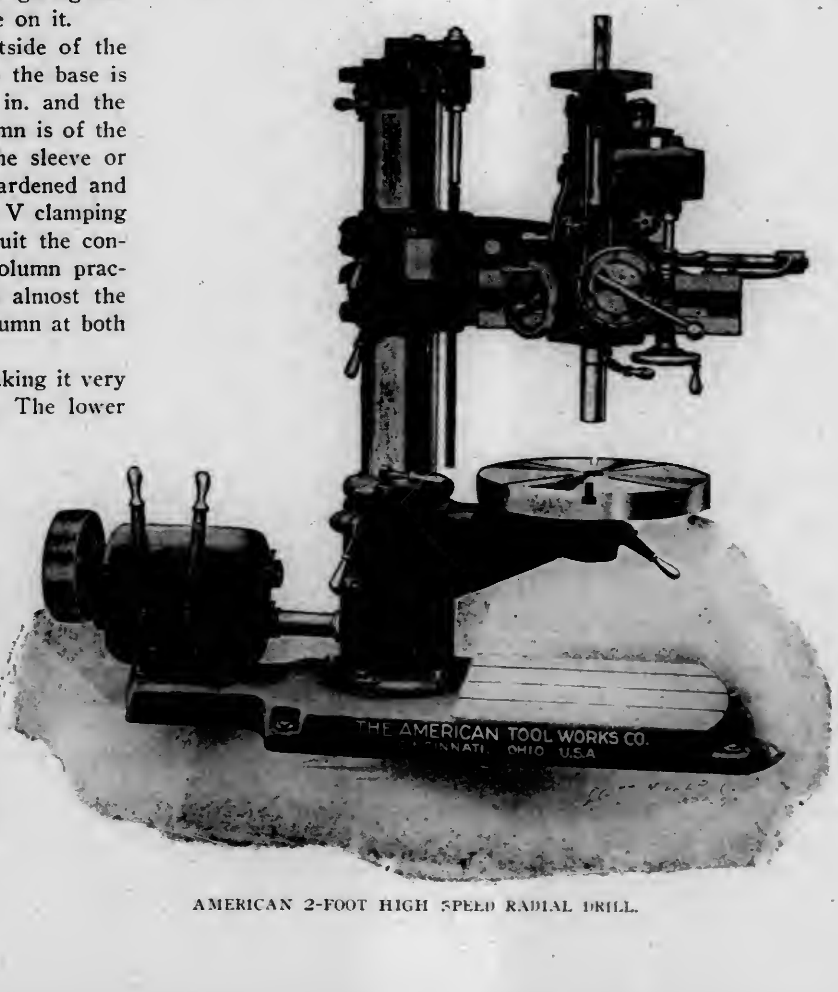
Size Drill	Speeds		Feeds		Back Gears		Actual H.P.	Amp.	Volts
	Revol's	Cutting Speed	Per Revol'n	Ins. Per Min.	Ratio	Positn.			
¾" H.S.	406.	79.7	.007"	2.84	1.5	Top	5.01	17	230
¾" H.S.	406.	79.7	.011"	4.46	1.5	"	11.8	40	"
¾" H.S.	290.	56.9	.020"	5.8	1.5	"	5.01	20	220
1 1/32 H.S.	290.	78.3	.011"	3.2	1.5	"	5.9	20	"
1 23/32 H.S.	106.5	47.9	.011"	1.17	5.72	Bottom	8.4	28	"
1 27/32 H.S.	76.	36.6	.011"	.84	5.72	"	5.3	18	"
	76.	36.6	.015"	1.14	5.72	"	6.2	21	"
	76.	36.6	.020"	1.52	5.72	"	8.4	28	"

TAPPING TEST WITH PIPE TAPS IN CAST STEEL 1⅛" THICK.

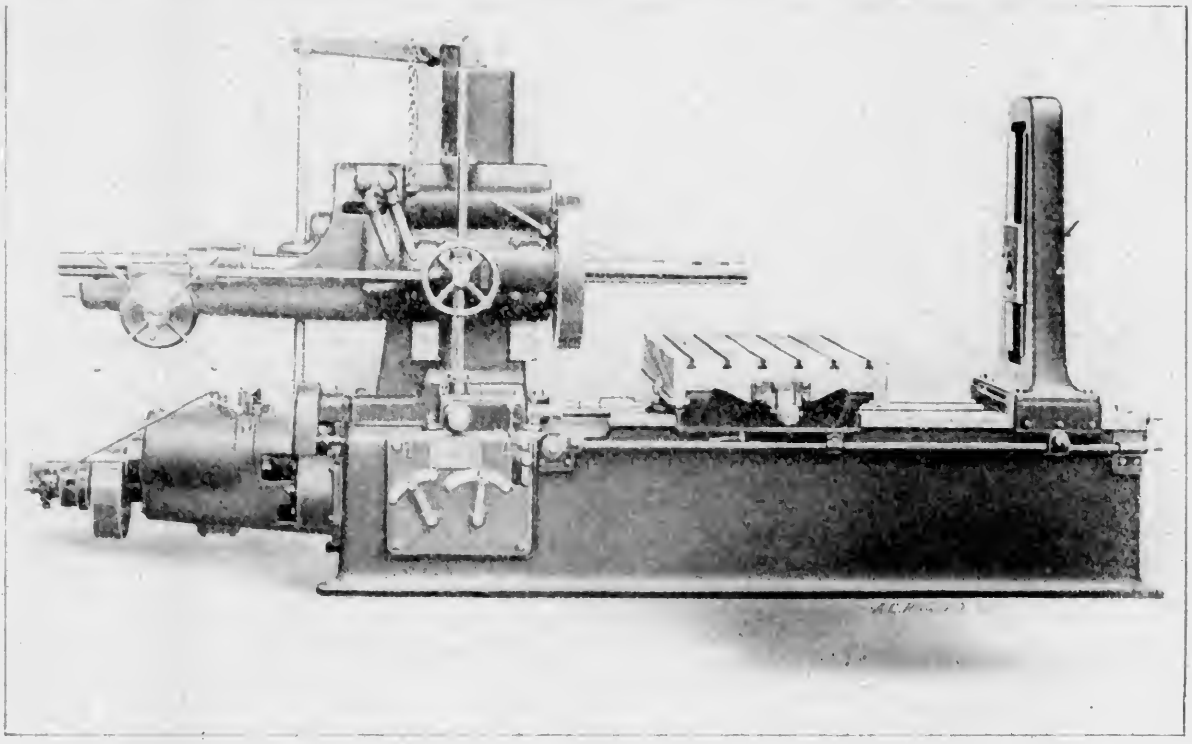
Diameter Tap	Speeds		Feeds		Back Gears		Actual H. P.	Amp.	Volts
	Rev'ns.	Cutting Speed	Per Revol'n	Ins. per Min.	Ratio	Posit'n			
2½	38.5	28.9	⅛"	4.8	5.72	Bottom	9.14	31	220
3	38.5	35.2	⅛"	4.8	5.72	"	9.7	33	220

TEST IN CAST IRON 1⅛" THICK.

2"	40	24.8	1/11.5"	3.4"	5.72	Bottom	4.24	14	226
2½"	40	30.1	⅛"	5"	5.72	"	5.15	17	226
3"	40	36.6	⅛"	5"	5.72	"	5.75	19	226



AMERICAN 2-FOOT HIGH SPEED RADIAL DRILL.



HORIZONTAL BORING, DRILLING AND MILLING MACHINE.

HORIZONTAL BORING, DRILLING AND MILLING MACHINE.

The No. 3 "Precision" horizontal boring, drilling and milling machine shown in the illustration is giving splendid results in the railroad shops in which it is being used, because of its accuracy and adaptability to a wide range of work. Special attention has been given to the design and construction of this type of machine to make it as useful for tool room work, requiring great accuracy, as for general manufacture, where power and rigidity are the principal essentials. To illustrate its adaptability two examples may be taken from railroad shop practice: the holes may be bored in a tumbling shaft and the hubs faced parallel, and true with the holes, by milling at one setting; air pump cylinders may be bored and both ends faced by milling at one setting.

It will be seen that instead of raising and lowering the platen with its load, the weight of which is widely variable, the spindle head, which is a constant weight, is raised and lowered. This construction allows the use of a deep box bed of great stiffness, which gives a solid foundation to the other members of the machine and keeps them in accurate relation to each other in all positions; for this reason the machine does not require a special foundation and its location is not confined to the ground floor. Not only can work be bored, drilled and milled at one setting, but because of the "Precision" screws, with graduated dials, the work can be done accurately, without any measuring or any of the usual necessary preliminaries. A large amount of extra handling and setting is therefore eliminated, greatly increasing the capacity of the machine. This construction also allows the addition of the vertical power feed for milling purposes, which is a very valuable feature for many classes of work.

The spindle is of unannealed hammered crucible steel, is accurately ground its entire length, and has a long bearing in the sleeve. It is forged and turned at least six months before it is finished and is allowed to "season" between every operation in its manufacture. The front of the driving gear forms a face plate to which the facing head, face milling cutters, or other large tools may be attached. Milling feeds to the platen and head (which includes the outer support for the boring bar) make the machine universal and capable of finishing at one setting many pieces which would otherwise require resetting and finishing on other machines. The addition of a graduated revolving table makes it possible to bore and drill holes and to mill surfaces at various angles.

The power cross feed to the platen, of good length, makes the machine complete for milling purposes, thus increasing its usefulness and making it possible to produce work which requires this feature at a lower cost, due to the elimination of rehandling and resetting; it also makes it possible to keep the machine running where it might otherwise have to lay idle, thus increasing its earning capacity. The length of the cross feed to the platen is great enough so that in many cases a job may be made ready at one end while the machine is boring another piece at the other end.

The yoke is adjusted along the bed with a wrench, and since there is a geared connection between the two screws that adjust the spindle head and the outer support for the boring bar, which is in the yoke, the outer support is kept in alignment with the spindle and cannot be thrown out by chips getting under the yoke, since it is fitted to the bed. The yoke may be entirely removed and then be put back in its original position without disturbing the alignment of the outer support for the boring bar with the spindle. This is a valuable feature where it is necessary to do work on pieces which are longer than the normal capacity of the machine. The outer support for the boring bar is bored after the machine is assembled, thus insuring its perfect alignment with the spindle.

The driving gears in the speed box are made of steel and are controlled by two levers giving nine changes of speed. Two levers on the head of the machine, which are interlocked, multiply this by two, making a total of eighteen changes of speed in geometrical progression. At each spindle speed only such gears as are in mesh as are used to obtain that speed and there is, therefore, no frictional loss due to the revolving of idle gears. The driving pulley runs on a stationary bushing and the belt pull does not come on the driving shaft. The main driving clutch is operated by a lever at the front of the machine within easy reach of the operator; when the machine is stopped only the driving pulley continues in motion. A direct connected motor drive may be applied if desired.

The feed motion is taken from one of the driving shafts, which runs at a higher speed than the spindle. This makes it possible to obtain the coarse feeds without gearing up, thus avoiding excessive strain on the feed gears and bearings and allowing the feed train to do its work easily. The fine feeds are

obtained by gearing down. Another advantage of this arrangement is that it gives two series of feeds, a coarse series with the back gears *in* and a fine series with the back gears *out*. There are 18 variations of feed, nine for either position of the spindle back gears, from .005 to .537 in. per revolution of the spindle. The rate of feed is the same for every part to which it is applied. The machine is regularly supplied with automatic feed to the spindle, automatic cross feed and vertical feed to the head. The head and outer support for the boring bar may be quickly moved by power and may also be moved by hand from both the front and end of the machine.

The adjustments of the spindle head, the outer support for the boring bar and the platen are made by "Precision" screws. These are provided with dials graduated to read to thousandths of an inch, thus allowing holes to be bored or drilled, and surfaces to be milled, at an exact distance apart, making it possible to easily produce interchangeable work without the use of jigs, or jigs may be originated on the machine more quickly and accurately than by any other method.

The platen is of extra size and thickness and has finished T-slots. It will be seen that it is especially deep, the aim being to make it so stiff that with ordinary care there will be no appreciable springing when the work is clamped upon it.

The machine illustrated is at present the largest of the various sizes which are made by the Lucas Machine Tool Company of Cleveland, O. It has a spindle 4 in. in diameter with 60 in. total traverse. The greatest distance between the face plate and the outer support for the boring bar is 6 ft. The greatest distance from the top of the platen to the center of the spindle is 26 in. The platen, which is 30 in. wide and 48 in. long, has a cross feed of 36 in.

2-FOOT BACK GEARED, HIGH SPEED, RADIAL DRILL.

The 2-ft. back geared, high speed, radial drill, illustrated herewith, has been designed by the American Tool Works Company of Cincinnati to meet the demand as a substitute for the larger sizes of upright drills, over which it has many advantages. That this machine is well adapted for the most severe service may be seen from the accompanying tables giving the results of a number of tests which have been made on it.

It drills to the center of a 4 ft. 5 in. circle, outside of the column. The greatest distance from the spindle to the base is 3 ft. 9-1-½ in.; the spindle has a traverse of 11 in. and the head has a traverse of 16 in. on the arm. The column is of the double tubular type and is exceptionally rigid. The sleeve or outer column revolves on conical roller bearings, hardened and ground, and is clamped in any position by a patent V clamping ring, which may be moved around the column to suit the convenience of the operator. This makes the outer column practically integral with the inner one, which extends almost the entire height and has full bearings for the outer column at both top and bottom.

The arm is of parabolic beam and tube section, making it very strong for resisting bending and torsional strains. The lower edge is parallel with the base, thus permitting work to be operated upon close to the column without the necessity for an extreme reach of the spindle. The arm is clamped to the column by two binder levers and is provided with a gib screw permitting the arm to work freely, without sagging, while the binder handles are loose. It is raised and lowered rapidly by a double thread coarse pitch screw, which may be controlled instantly by a convenient lever, arrow points indicating the proper direction. The head may be moved rapidly along the arm by a hand wheel which operates an angular rack and spiral rack pinion. It may be locked in any position. The back gears are located on the head, thus bringing the greatest speed reduction direct to the spindle; it may be engaged or disengaged while the machine is in operation.

The speed box is of the geared friction type, is very powerful and provides four changes of speed, any one of which may be instantly obtained by the two levers. This in combination

DRILLING TEST IN CAST IRON 2" THICK.

Size Drill	Speeds: Revol's	Speeds: Cutting Speed	Feeds: Per Revol'n	Feeds: Ins Per Min	Back Gears: Ratio	Back Gears: Posit'n	Actual H P	Amp	Volts
[illegible] H S.	200	[illegible]	.015"	4.35	[illegible]	Top	[illegible]	[illegible]	[illegible]
[illegible] H S	4[illegible]	70.7	.020"	8.12	1.5	"	[illegible]	2[illegible]	
1[illegible] H S	[illegible]	[illegible]	.020"	8.[illegible]	1.5		[illegible] 40	2[illegible]	
1[illegible]" H S	[illegible]	116.2	.020"	8.12	[illegible]		41.4		
1[illegible] H S	[illegible]	112.1	.015	1.[illegible]	[illegible]		[illegible]		
1[illegible] H S	[illegible]	11[illegible].1	.02[illegible]	5	[illegible]		[illegible]	4[illegible]	
1[illegible] H S	[illegible]	[illegible]	[illegible]	1.3[illegible]	1.[illegible]		[illegible]	[illegible]	
1½ H S	[illegible]	[illegible]	.0[illegible]	3.11	1.5		[illegible]	[illegible]	

DRILLING TEST IN STEEL 3" THICK.

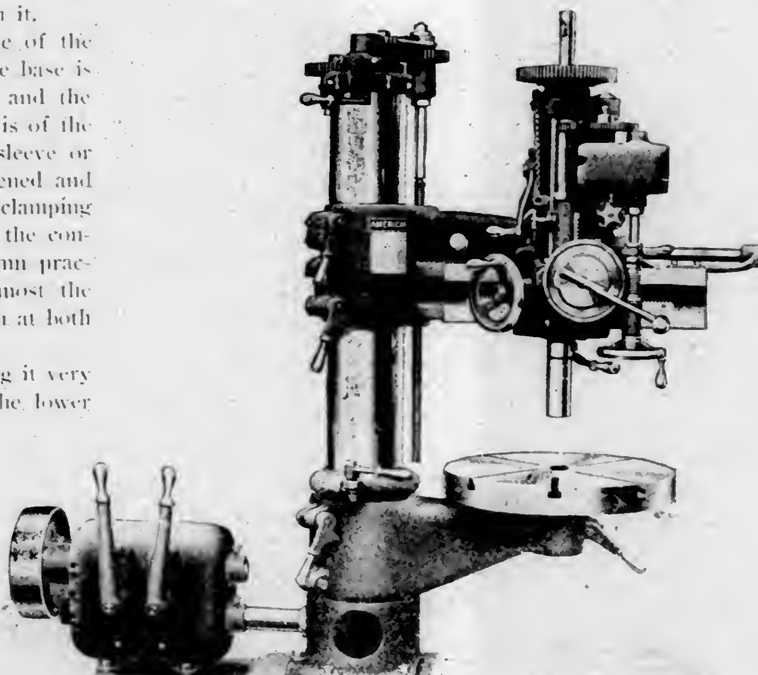
Size Drill	Speeds: Revol's	Speeds: Cutting Speed	Feeds: Per Revol'n	Feeds: Ins Per Min	Back Gears: Ratio	Back Gears: Posit'n	Actual H P	Amp	Volts
[illegible]" H S	[illegible]	[illegible]7	.[illegible]7	[illegible]1	1.5	Top	5.[illegible]	[illegible]	[illegible]
[illegible]" H S	400	[illegible]7	.011"	1.46	1.5		11.[illegible]	[illegible]	
[illegible]" H S	200	[illegible]	.02[illegible]	5.8	1.5		5.[illegible]	2[illegible]	[illegible]
1[illegible] H S	[illegible]	[illegible]3	.011	3.2	1.5		3.[illegible]	[illegible]	
1[illegible] H S	106.5	[illegible]	.011"	1.17	5.72	Bottom	[illegible]4	[illegible]	
1[illegible] H S	76	30.[illegible]	.011	.84	5.72		5.[illegible]	1[illegible]	
	76	30.6	.015	1.14	5.72		[illegible]2	[illegible]	
	76	30.6	.02[illegible]	1.52	5.72		[illegible]1	[illegible]	

TAPPING TEST WITH PIPE TAPS IN CAST STEEL 1¼" THICK.

Diameter Tap	Speeds: Rev'ns.	Speeds: Cutting Speed	Feeds: Per Revol'n	Feeds: Ins per Min.	Back Gears: Ratio	Back Gears: Posit'n	Actual H. P.	Amp	Volts
2½	38.5	28.9	[illegible]"	4.[illegible]	5.72	Bottom	9.14	31	220
3	38.5	35.2	[illegible]"	4.8	5.72	"	9.7	33	229

TEST IN CAST IRON 1⅛" THICK.

2"	[illegible]	21.[illegible]	1 11.5"	3.[illegible]"	5.72	Bottom	[illegible].21	14	226
2½"	40	30.1	[illegible]"	5"	5.72	"	5.15	17	22[illegible]
3"	[illegible]	30.6	[illegible]"	5"	5.72	"	5.75	19	22[illegible]



AMERICAN 2-FOOT HIGH SPEED RADIAL DRILL.

with the back gears on the head furnishes 16 spindle speeds ranging from 34 to 400 r. p. m., in geometrical progression. Any one of these is instantly available without stopping the machine. An engraved speed plate enables the operator to select the proper speed for either carbon or high speed drills, also for boring and tapping. The spindle is counterbalanced and has a frictional quick advance and return.

Four feeds are provided, from .007 to .020 in., in geometrical progression. Any one of these may easily be obtained by turning a knob on the feed box until the desired feed, shown on the dial, comes opposite a fixed pointer. The feeds operate through a friction, which permits the drill being crowded to its limit without straining the feed works. The feeds may be automatically tripped at any position of the spindle by an adjustable trip dog and pointer, acting on the worm clutch. Depth graduations are on the spindle and all depths may be read from zero. A safety stop acts automatically at the full depth of the spindle, preventing breakage to the head. A tapping mechanism is carried on the head between the gears and the speed box, thus giving the frictions, already powerful, the benefit of the back gear ratios, making unusually heavy tapping operations possible and permitting the taps to be backed out at an accelerated speed. The lever for starting, stopping or reversing the spindle is controlled from the front of the machine.

The heavy service to which machines of this type are being subjected makes it necessary to provide good lubrication for all of the bearings, and this feature has been given special attention. Motors of any type may be applied and may drive either direct or through gears, chains or belts. The makers, whose offices are in Cincinnati, recommend connecting the motor direct to the gear box through gearing.

MACHINE TOOL EXHIBIT AT ATLANTIC CITY.

The display of machine tools at the Atlantic City exhibition this year was very impressive, both as to the quality and number of machines shown (practically all in operation), as well as the general arrangement of this section of the exhibition. It will be impossible in the short space available to go into any extended description of these machines, but a brief mention of some of the more important ones will indicate the extent and value of the collection.

The Lodge and Shipley Machine Tool Co., Cincinnati, O., exhibited a couple of interesting lathes, one being a 24 in. x 12 ft. patent head, standard screw cutting, engine lathe, direct driven by a 10 h.p. motor. This lathe has six mechanical speed changes in the head stock and a speed variation from 450 to 900 r. p. m. in the motor (20 changes). It has 32 feed changes and the same number of threading changes, all of which can be made while the lathe is running. A handy machine in the shape of a 16 in. motor driven portable lathe mounted on wheels for use in the roundhouse, or in the erecting shop, was also exhibited by the same company.

The Springfield Machine Tool Co., Springfield, O., exhibited a 19 in. high power rapid reduction lathe with power transmitted from the motor by a silent chain drive instead of by gearing. It is driven by a 7½ h.p. motor with a speed range of 500 to 1,000 r. p. m.; with a constant speed motor eight mechanical speed changes may be obtained. The control of the motor is located on the apron at a convenient point.

The Gisholt Machine Co., Madison, Wis., exhibited a 24 in. turret lathe, with a 6¼ in. hole through the spindle, which attracted much attention. The operation of this type of machine was illustrated and described on page 246 of the June issue of this journal. The same company also showed a 52 in. vertical boring mill, equipped with a number of new labor and time saving devices, which greatly assist in increasing the output and decreasing the difficulty of operation.

The Cincinnati Milling Machine Company exhibited a vertical high power miller which has a capacity for removing 10 cu. ft. of steel per minute. It is direct connected to a 10 h.p. motor, thus giving a capacity of 1 cu. in. of steel per net horse-power minute.

Bardons & Oliver, Cleveland, O., showed a large automatic chuck, turret lathe having a capacity of 4½ x 30 in. This lathe is well adapted for making locomotive wrist pins, knuckle pins, large bushings, etc. It has a geared head driven by a constant speed motor of 15 h.p. A small turret lathe for brass work was also exhibited by this company.

The Lucas Machine Tool Company of Cleveland, O., showed a large boring, drilling and milling machine. It is intended to be universal and is capable of finishing at one setting many pieces of work which would otherwise require resetting on other machines. A full description of this machine will be found elsewhere in this issue. A 50 ton power forcing press, specially adapted for railroad shop use, was also exhibited by this company.

The Brown & Sharpe Co. exhibited three milling machines which represent new ideas in the design of milling machines in the use of a constant speed drive. The No. 5 B heavy plain milling or slabbing machine made by this company will remove cast iron at the rate of 30 cu. in. per minute. This machine has a vertical spindle attachment which was exhibited separately.

The Cincinnati Planer Co. exhibited a 37 in. variable speed heavy forge planer which is arranged for four changes of cutting speed, from 20 to 45 ft. per minute, the return speed being constant. It was driven by a 15 h.p. constant speed motor. With a cutting speed of 40 ft. per min. and a return speed of 80 ft. per min. it cuts 1,600 ft. per hr.

The only shaper exhibited was one by Gould & Eberhardt, which was shown in the General Electric Company's exhibit. It was a 24-in. stroke machine, equipped with a 5 h.p. motor.

The Cincinnati Machine Tool Co. exhibited a heavy, new pattern, sliding head drill with a patent geared tapping adjustment with which the spindle can be driven forward, stopped and reversed at increased speed for tapping purposes. It has a patent positive geared feed; any one of the six feeds may be quickly and easily obtained. This machine was built specially for use with high speed steel twist drills and is motor driven, the motor furnishing 19 spindle speeds, which in conjunction with the back gears gave a total of 38 spindle speeds. A sensitive drill was also exhibited by the same company.

The Bickford Drill & Tool Company, Cincinnati, O., exhibited a full universal radial drill in operation, which presented a number of new features in design. It is said to possess the same power and stiffness as a plain drilling machine. It has capacity for driving a 5 in. pipe tap. A speed box in connection with back gears furnished 24 speed changes.

Baker Bros., Toledo, O., exhibited a heavy drill press especially adapted for high speed drills. This machine has a record for drilling 2 in. holes in cast iron at a speed of 350 r. p. m. and a feed of 26 in. per minute.

The T. C. Dill Machine Co., Philadelphia, exhibited a 15 in. Dill slotter. It is equipped with a traveling head, a quick traverse and a new quick return motion. It is furnished with 6 changes of speed and was driven by a 5 h.p. motor.

The Diamond Machine Co., Providence, R. I., showed an 84 in. locomotive guide face-grinder especially designed for grinding case hardened locomotive guides. A tool grinding machine was also exhibited by this company.

The Landis Tool Co., Waynesboro, Pa., exhibited a universal grinding machine with automatic heads. This machine has a 12 in. swing and is 42 in. between centers.

Wm. Sellers & Co. showed two standard tool grinders and one twist drill grinder. They demonstrated the efficiency of these machines by grinding the tools for the other machine tool exhibitors.

Chas. H. Besley & Co., Chicago, exhibited a spiral disc grinder.

The Landis Machine Co., Waynesboro, Pa., exhibited a 2 in. single, motor driven, bolt cutter with the Landis patent, all steel, die head.

The National Acme Mfg. Co., Cleveland, O., exhibited an interesting automatic multiple-spindle screw machine in which four bars are operated at one time, one set of tools being used. This machine will allow eight or more operations to be easily performed at the same time. It has a chucking capacity of 2¼ in.

The Stoever Foundry & Mfg. Co., Lebanon, Pa., exhibited a motor driven pipe machine, the connection from the constant speed motor to the main driving gear being by silent chain.

FISHER PARALLEL LEG VISE.

The accompanying illustration shows the Fisher double screw parallel leg vise which is manufactured by the Eagle Anvil Works of Trenton, N. J. This vise has all of the well-known advantages of the old-fashioned leg vise, with such alterations as will overcome the very important disadvantage of that type, *i. e.*, the angularity of jaw faces. This action is obtained by the addition of a second screw located at the lower end of the vise, which has the same pitch as the upper screw and is driven at the same speed by means of a chain and gears, so that the lower end of the jaw moves exactly the same distance as the upper end and always maintains the faces in a parallel position.

It requires little power to move this lower screw, because in tightening up on the piece of work between the jaws, the tendency of the lower end is to move inward and there is no strain on the screw, the chain simply regulating the movement. In opening the vise there is, of course, no strain on either of the screws, therefore the chain has little wear and is as durable as the other parts of the vise.

The jaws are of the best cast tool steel, welded on, file cut, properly hardened, and of convenient shape for the workman to get near his work equally well for filing or chipping. A slot slide and guide is arranged just above the lower screw and prevents any twisting of the front jaw.

This company also manufacture the "Eagle" anvil, which can be furnished in all sizes with special arrangements for different classes of work. One of these anvils is particularly adapted for railroad shop work, others for tool makers, etc.

PERSONALS.

O. M. Stimson, master car builder of the Swift Refrigerator Transportation Co., has resigned.

C. H. Burk has resigned as assistant superintendent of machinery of the Mexican Central Ry.

W. F. Kaderly, master mechanic of the Southern Ry., has been transferred from Alexandria, Va., to Spencer, N. C.

W. S. Stone has been re-elected grand chief engineer of the International Brotherhood of Locomotive Engineers.

B. R. Moore has resigned as assistant superintendent of motive power and machinery of the Chicago, St. Paul, Minneapolis & Omaha Ry.

G. N. Howson, master mechanic of the Southern Ry. at Charleston, S. C., will succeed Mr. Kaderly as master mechanic at Alexandria, Va.

G. W. Hedge has been appointed assistant master mechanic of the Canadian Northern Ry. at Winnipeg, Man., to succeed G. S. McKennon.

W. J. Haynen has been appointed master mechanic of the Gulf and Ship Island Ry., with office at Gulfport, Miss., succeeding A. Bardsley, resigned.

D. N. Toomey, traveling engineer of the Southern Pacific R. R., has been appointed general master mechanic, with headquarters at San Antonio, Tex.

At the thirty-fourth annual commencement of Purdue University, the honorary degree of Doctor of Engineering was conferred upon Mr. Angus Sinclair.

J. L. Schick has been appointed storekeeper of the New York, Susquehanna & Western R. R., with headquarters at Stroudsburgh, Pa., succeeding F. C. Pearce, resigned.

W. Byrd Page has resigned as master mechanic of the Pennsylvania R. R. at Camden, N. J., to become assistant superintendent of machinery of the Mexican Central Ry., succeeding C. H. Burk.

W. H. Clarkson, formerly master mechanic of the Northern Pacific shops at Livingston, Mont., is reported to have entered the service of the Guggenheims as master mechanic of railroads and mines in Alaska.

F. M. McNulty, master mechanic of the Monongahela Connecting R. R., at Pittsburg, has been appointed superintendent of motive power and rolling stock, and will also perform the duties of master car builder.

Dr. Charles H. Benjamin, Dean of the Schools of Engineering of Purdue University, received the honorary degree of "Doctor of Engineering" at the recent commencement of the Case School of Applied Science, Cleveland.

CATALOGS

IN WRITING FOR THESE PLEASE MENTION THIS JOURNAL.

CINCINNATI SHAPERS.—The Cincinnati Shaper Co., Elam street and Garrard avenue, Cincinnati, O., is issuing catalog F, which is composed of seventy pages of most excellent illustrations, both half tone and line drawings, of the very large line of shapers manufactured by this company. The machines are thoroughly described, illustrations of details forming a very valuable part of the information. The illustrations, being printed on the heaviest type of coated paper, are exceptionally clear and valuable. Shapers are shown in practically every conceivable arrangement, size and capacity.

TANKS.—The W. E. Caldwell Company, Louisville, Ky., is issuing the twentieth annual edition of its catalog. This company builds every variety of tank for any desired purpose, of either steel or wood, and supplies all fixtures and fittings used in connection with any kind of a tank or water supply job. For wooden tanks a specialty has been made for years of the use of Louisiana Red Gulf cypress, which is recognized as an ideal wood for tank purposes; other woods, however, are used for tanks if desired by the purchaser. This catalog gives a very complete list of the dimensions, capacities and prices of the various sizes and types of tanks and fittings.

ELECTRICAL APPARATUS.—Among the bulletins recently issued by the General Electric Company, Schenectady, N. Y., might be mentioned No. 4588, describing the G. E. 202 railway motor, which is similar in design and construction to the latest standard G. E. railway motors and in addition is provided with commutating poles, allowing the overload to be considerably increased. Other bulletins are being issued on the subjects of Tungsten economy diffusers (No. 4594); aluminum lightning arresters (No. 4595); flaming arc lamps (No. 4586), and electrically heated household appliances (in pamphlet form).

PUNCHING AND SHEARING MACHINERY.—The Cincinnati Punch and Shear Co., Cincinnati, O., is issuing catalog No. 11. This company are the designers and builders of heavy power bending and straightening rolls, punching machines, coping machines, rolling mill and tin mill machinery, multiple punches, gate and universal shears, and sheet doublers. These machines are all furnished in either belt, engine or motor driven design. The present catalog, which is given up largely to punching and shearing machinery, contains excellent illustrations and brief descriptions of a great variety of designs. Machines for special work form an important part of the catalog.

OXY-ACETYLENE WELDING AND CUTTING.—The Davis-Bournonville Acetylene Development Co., 90 West street, New York City, is issuing a leaflet giving preliminary information concerning welding and cutting by means of the oxy-acetylene flame.

COAL HANDLING MACHINERY.—The C. W. Hunt Company, 45 Broadway, New York, is issuing a small pamphlet which forms an introduction to a general line of labor saving machinery manufactured by it. It gives illustrations and descriptions of many different types of coal handling machinery, both elevator and conveyor. Also steam hoisting engines, industrial track, coal gates, narrow gauge cars, etc.

RAILWAY SPECIALTIES.—The General Railway Supply Company, 922 Marquette Bldg., Chicago, is issuing a very attractive catalog describing a number of its more important specialties. These include metallic (steel) sheathing for passenger coaches, which has many advantages over wood and presents an equally good appearance with a much smaller maintenance charge. This type of sheathing is now becoming very popular for high class passenger equipment. The National steel trap door and lifting device for wide vestibule cars is also illustrated and described. This is made of pressed steel plates in one piece and is arranged to raise to an angle of 45 degrees of its own accord as soon as the latch is thrown. Beyond this point it has to be pushed into place and thus prevents any possibility of passengers accidentally falling through the opening. Other specialties of this company shown in this catalog comprise the Schroyer friction curtain roller, which eliminates the necessity of pinch handles and compression bars on the bottom of the curtain. The Garland ventilator, which is based on the aspirator or exhaust principle and is capable of exhausting 15,000 cu. ft. of air per ventilator from a car running at 30 miles per hour. The Flexolith composition flooring, which is laid in plastic form over either old or new wood floor and possesses many excellent features, particularly along sanitary lines, is handled by this company. The catalog also includes illustrations and descriptions of National vestibule curtain catches; National standard roofing for passenger coaches, and the Ideal roller center plates.

NOTES

THE ENGINEERS' CLUB OF PHILADELPHIA.—The above organization calls attention to its change of address, which is now 1317 Spruce street, Philadelphia.

AMERICAN LOCOMOTIVE COMPANY.—The above company has recently received an order for a 3 ft. 6 in. gauge Mogul tank locomotive from the Imperial Taiwan Railway of Japan.

STANDARD ROLLER BEARING COMPANY.—T. F. Salter, well known as an engineer in the field of hoisting and conveying apparatus, has accepted the position of chief engineer of this company.

INDIANAPOLIS BRANCH—H. W. JOHNS-MANVILLE CO.—A new office of the above company, whose main office is at 100 William street, New York, has recently been opened at 30 South Pennsylvania street, Indianapolis. This office is under the management of Charles E. Wehr.

THE STANDARD ROLLER BEARING COMPANY announces that it has recently installed at its foundry at Philadelphia a thoroughly equipped testing laboratory, which is in charge of Walter H. Hart, an expert chemist, formerly connected with the Alan Wood Iron and Steel Company. This company has recently opened a branch office at 327 Jefferson avenue, Detroit, which is in charge of Ernest L. Smith, recently appointed western representative.

THE CONSOLIDATED SUPPLY COMPANY.—This company has been incorporated and will make a specialty in handling general steam and electric railway, mill and mining supplies, with headquarters at 321 Dearborn street, Chicago, Ill. The office and store occupy the ground floor In the Manhattan Building, the storeroom extending through and fronting on No. 60 Plymouth place. The incorporators are L. C. Hopkins, John P. Mahoney and J. L. Benedict. Mr. Hopkins has had some eight years' experience in the railroad and supply business. For the past year he has been connected with the sales department of the Chicago Pneumatic Tool Company, and previous to that was four years with Fairbanks, Morse & Company. Mr. Mahoney was formerly chief clerk to the purchasing agent of the T. St. L. & W. Ry. Mr. Benedict has been in the railroad business ten years and for the past five or six years has been connected with the Chicago Pneumatic Tool Company, as manager of the Chicago office and on the road.

CONVENTION EXHIBITS.

Young's Million Dollar Pier afforded splendid facilities for exhibition purposes. The exhibits were greater in number and far better arranged than those of any previous convention. Among the companies having exhibits, or having representatives at the convention, were the following:

Adams & Westlake Co., Chicago.
Ajax Manufacturing Company, Cleveland, O.
American Balance Valve Co., Jersey Shore, Pa.
American Blower Co., Detroit, Mich.
American Brake Shoe & Foundry Co., Mahwah, N. J.
American Car & Foundry Co., St. Louis.
American Locomotive Company, New York.
American Nut & Bolt Fastener Company, Pittsburg, Pa.
American Steam Gauge & Valve Mfg. Company, Boston, Mass.
American Steel Foundries and Simplex Railway Appliance Co., Chicago.
American Tool Works Company, Cincinnati, O.
American Vanadium Company, Pittsburg, Pa.
American Water Softener Company, Philadelphia, Pa.
Anchor Packing Company, Philadelphia, Pa.
Baldwin Locomotive Works, Philadelphia, Pa.
Bardons & Oliver, Cleveland, O.
Beaudry & Co., Boston, Mass.
Bettendorf Axle Co., Davenport, Ia.
Bickford Drill & Tool Co., Cincinnati, O.
Bliss Electric Car Lighting Co., Milwaukee, Wis.
Bowser, S. F. & Co., Fort Wayne, Ind.
Brewer Bros. Co., Philadelphia.
Brill Company, J. G.. Philadelphia.
Buckeye Steel Castings Co., Columbus, O.
Bush & McCormick, Columbus, O.
Butler Drawbar Attachment Co., Cleveland, O.
Cardwell Mfg. Co., Chicago, Ill.
Carey, Philip, Mfg. Co., Cincinnati, O.
Carter Iron Company.
Celfor Tool Company, Chicago.
Champion Rivet Co., Cleveland, O.
Chicago Car Heating Co., Chicago.
Chicago Pneumatic Tool Co., Chicago.
Cincinnati Machine Tool Co., Cincinnati, O.
Cincinnati Milling Machine Co., Cincinnati, O.
Cincinnati Planer Co., Cincinnati, O.
Cleveland Car Specialty Co., Cleveland, O.
Commonwealth Steel Co., St. Louis.
Davis Solid Truss Brake Beam Co., Wilmington, Del.
Dearborn Drug & Chemical Works, Chicago.
Detroit Lubricator Co., Detroit, Mich.
Dickinson, Paul, Inc., Chicago.
Dill Machine Co., T. C., Philadelphia.
Dixon Crucible Co., Jos., Jersey City, N. J.
Dressel Railway Lamp Works, New York.
Drouve Co., G., Bridgeport, Conn.
Duner Co., Chicago.
Edwards Co., O. M., Syracuse, N. Y.
Electric Storage Battery Co., Philadelphia.
Falls Hollow Staybolt Co., Cuyahoga Falls, O.
Farlow Draft Gear Co., Baltimore, Md.
Flannery Bolt Co., Pittsburg, Pa.
Flexible Compound Co., Philadelphia.
France Packing Co., Tacony, Pa.
Franklin Mfg. Co., Franklin, Pa.
Frost Railway Supply Co., Detroit, Mich.
Fuller Iron & Steel Company, H. A., St. Louis, Mo.
Galena-Signal Oil Co., Franklin, Pa.
General Electric Company, Schenectady, N. Y.
General Railway Supply Company, Chicago.
Gisholt Machine Co., Madison, Wis.
Goldschmidt Thermit Company, New York.
Goodwin Car Company, New York.
Gould Coupler Company, New York.
Griffith Folding Vestibule Trap.
Grip Nut Company, Chicago.
Homestead Valve Mfg. Co., Homestead, Pa.
Invisible Roll Screen Co., Brooklyn, N. Y.
Johns-Manville Co., H. W., New York.
Kennicott Water Softener Company, Chicago.
Lancaster Machine & Knife Works, Lancaster, N. J.
Landis Machine Co., Waynesboro, Pa.
Landis Tool Company, Waynesboro, Pa.
Lawrenceville Bronze Company, Pittsburg, Pa.
Locomotive Appliance Company, Chicago.
Lodge & Shipley Machine Tool Co., Cincinnati.
Love Brake Shoe Co., Chicago.
Lucas Machine Tool Co., Cleveland, O.
McConway & Torley Co., Pittsburg, Pa.
McCord & Co., Chicago.
Maltby, Geo. B., Cleveland.
Marshall & Huschart Machinery Co., Chicago.
Michigan Lubricator Co., Detroit, Mich.
Murphy & Company, Christopher, Chicago, Ill.
Nathan Manufacturing Company, New York.
National-Acme Manufacturing Company, Cleveland, O.
National Aniline & Chemical Co., Philadelphia.
National Boiler Washing Co., Chicago.
National Malleable Castings Co., Cleveland, O.
National Roofing Company, Tonawanda, N. Y.
National Tube Company, Pittsburg, Pa.
Niles-Bement-Pond Company, New York.
Norton Company, Worcester, Mass.
Parkesburg Iron Company, Parkesburg, Pa.
Pittsburgh Emery Wheel Company, Pittsburg, Pa.
Pittsburg Equipment Co., Pittsburg, Pa.
Pressed Steel Car Company, Pittsburg.
Railway Materials Company, Chicago.
Ralston Steel Car Co., Columbus, O.
Restein Clement Co., Philadelphia.
Ritter Folding Door Co., Cincinnati.
Rubberset Brush Co., Newark, N. J.
Ryerson, Joseph T., & Son, Chicago.
Safety Car Heating & Lighting Co., New York.
St. Louis Surfacer & Paint Co., St. Louis, Mo.
Scullin-Gallagher Iron & Steel Co., St. Louis.
Scully Steel & Iron Co., Chicago.
Sellers, Wm., & Co., Inc., Philadelphia.
Smith Company, Chas. G., Pittsburg, Pa.
Smith Co., Wm. J., New Haven, Conn.
Springfield Machine Tool Co., Springfield, O.
Standard Car Truck Co., Chicago.
Standard Coupler Company, New York.
Standard Steel Car Company, Pittsburg, Pa.
Standard Steel Works Co., Philadelphia.
Sterling Steel Foundry Co., Pittsburg, Pa.
Stoever Fdy. & Mfg. Co., Lebanon, Pa.
Symington Co., T. H., Baltimore, Md.
Tindel-Morris Co., Eddystone, Pa.
Underwood, H. B., & Co., Philadelphia.
Vanadium Sales Company of America.
Ward Equipment Co., New York.
Watson-Stillman Co., New York.
Waugh Draft Gear Co., Chicago, Ill.
Western Railway Equipment Co., St. Louis.
Western Tool & Mfg. Co., Springfield, Ohio.
Westinghouse Companies, Pittsburg, Pa.
Wood, G. S., Chicago.
Whiting Fdy. Equipment Co., Harvey, Ill.
Wright Wrench Co., 3044 Chestnut St., Philadelphia.

COMPOUND, SUPERHEATED STEAM, MOTOR CAR

CHICAGO, ROCK ISLAND & PACIFIC RAILROAD.

The Schenectady Works of the American Locomotive Company has recently completed a steam motor car* for the Chicago, Rock Island & Pacific Railroad. The motive power of this car consists of a 250 h.p., two-cylinder compound steam engine having cylinders 9¼ and 14½ x 12 in. operated by superheated steam of 250 lbs. pressure generated in a horizontal return tubular boiler. The cylinders drive a pair of 38 inch wheels, forming the trailing wheels of the leading or motor truck. The car is of steel construction with interior finish of wood, is 55 ft. 9 in. total length, weighs 100,000 lbs. in working order and has a capacity of 40 passengers in addition to a good size baggage compartment. Test runs have shown it to be capable of speeds of 60 miles per hour. The distribution of weights is such as to give 38,300 lbs. on the trailing truck, and 61,700 lbs. on the motor truck, of which 32,400 lbs. is on the driving wheels. The theoretical tractive effort, working compound, is 4,300 lbs.

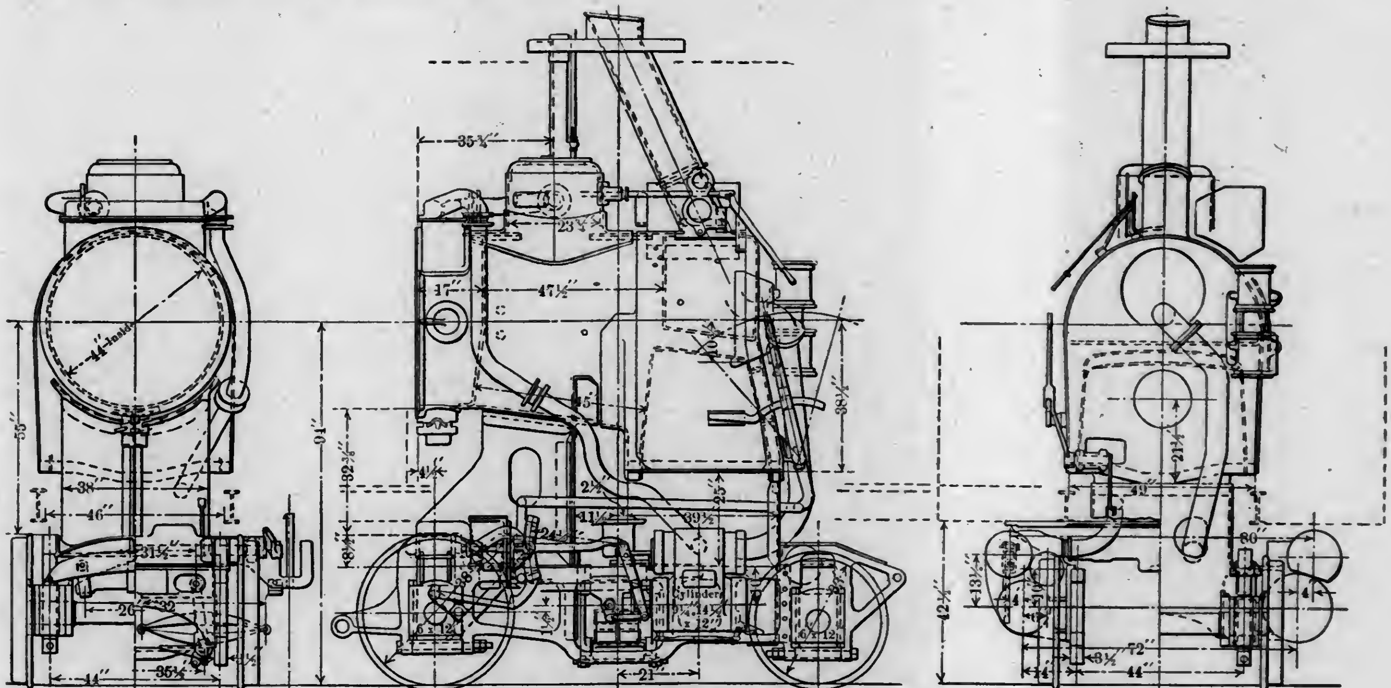
The car body was built at the Wilmington Works of the American Car & Foundry Co., and the primary object in the design was to make it as light as possible, consistent with the proper degree of strength for a car operating singly. With this in mind, a type of construction which employs truss rods for reinforcing the side sills was adopted. The framing and exterior sheathing are of steel and the interior finish is of mahogany.

The underframe consists of two 8 in. I-beams forming center sills and 6 x 4 x ½ in. steel angles reinforced by 1½ in. truss rods forming side sills. The side sills are further reinforced by another 6 x 4 x ½ in. angle for a distance of 20 ft. at the front end. The end sills are 8 in. steel channels and a number of steel angles are secured between the center and side sills between the bolsters. These cross braces, in addition to forming stiffeners, also serve as floor supports. The side posts are made up of angles riveted to the side sills and the side plates. The plates are in one continuous piece for the entire length of the car, being bent to form the proper contour at the end. The carlins are steel channels, continuous between side plates, bent to conform to the contour of the elliptical roof.

The bolster at the trailing end of the car is of the built up type, but that at the motor end is of cast steel made in three sections and secured in such a manner that the middle section may be readily removed and permit the motor, with its superimposed boiler, to be drawn out from the end of the car. The end sill and the center section of the front end framing of the car body, as well as the floor ahead of the boiler, are also made removable for the same purpose.

STEAM MOTOR CAR—CHICAGO, ROCK ISLAND AND PACIFIC RAILROAD.

* For description of other steam motor cars see this Journal 1906, pp. 294 and 331 (C. P. R.); 1907, pp. 141 (Ganz, C. R. I. & P.); 312 (Ganz, Erie); 391 (Intercolonial); 445 (Ganz, Intercolonial), and 317.



DETAILS OF STEAM MOTOR TRUCK—C., R. I. & P. R. R. MOTOR CAR.

Oxy-Acetylene Welding and Cutting.—The Davis-Bournonville Acetylene Development Co., 90 West street, New York City, is issuing a leaflet giving preliminary information concerning welding and cutting by means of the oxy-acetylene flame.

Coal Handling Machinery.—The C. W. Hunt Company, 45 Broadway, New York, is issuing a small pamphlet which forms an introduction to a general line of labor saving machinery manufactured by it. It gives illustrations and descriptions of many different types of coal handling machinery, both elevator and conveyor. Also steam hoisting engines, industrial track, coal gates, narrow gauge cars, etc.

Railway Specialties.—The General Railway Supply Company, 922 Marquette Bldg., Chicago, is issuing a very attractive catalog describing a number of its more important specialties. These include metallic (steel) sheathing for passenger coaches, which has many advantages over wood and presents an equally good appearance with a much smaller maintenance charge. This type of sheathing is now becoming very popular for first class passenger equipment. The National steel trap door and lifting device for vestibule cars is also illustrated and described. This is made of pressed steel plates in one piece and is arranged to raise to an angle of 45 degrees of its own accord as soon as the latch is thrown. Beyond this point it has to be pushed into place and thus prevents any possibility of passengers accidentally falling through the opening. Other specialties of this company shown in this catalog comprise the Schroyer friction curtain roller, which eliminates the necessity of pinch handles and compression bars on the bottom of the curtain. The Garland ventilator, which is based on the ejector or exhaust principle and is capable of exhausting 15,000 cu. ft. of air per ventilator from a car running at 30 miles per hour. The Flexolith composition flooring, which is laid in plastic form over either old or new wood floor and possesses many excellent features, particularly along sanitary lines, is handled by this company. The catalog also includes illustrations and descriptions of National vestibule curtain catches; National standard roofing for passenger coaches, and the Ideal roller center plates.

NOTES

The Engineers' Club of Philadelphia.—The above organization calls attention to its change of address, which is now 1317 Spruce street, Philadelphia.

American Locomotive Company.—The above company has recently received an order for a 3 ft. 6 in. gauge Mogul tank locomotive from the Imperial Taiwan Railway of Japan.

Standard Roller Bearing Company.—T. F. Salter, well known as an engineer in the field of hoisting and conveying apparatus, has accepted the position of chief engineer of this company.

Indianapolis Branch—H. W. Johns-Manville Co.—A new office of the above company, whose main office is at 100 William street, New York, has recently been opened at 30 South Pennsylvania street, Indianapolis. This office is under the management of Charles E. Wehr.

The Standard Roller Bearing Company announces that it has recently installed at its foundry at Philadelphia a thoroughly equipped testing laboratory, which is in charge of Walter H. Hart, an expert chemist, formerly connected with the Alan Wood Iron and Steel Company. This company has recently opened a branch office at 327 Jefferson avenue, Detroit, which is in charge of Ernest L. Smith, recently appointed western representative.

The Consolidated Supply Company.—This company has been incorporated and will make a specialty in handling general steam and electric railway, mill and mining supplies, with headquarters at 321 Dearborn street, Chicago, Ill. The office and store occupy the ground floor in the Manhattan Building, the storeroom extending through and fronting on No. 60 Plymouth place. The incorporators are L. C. Hopkins, John P. Mahoney and J. L. Benedict. Mr. Hopkins has had some eight years' experience in the railroad and supply business. For the past year he has been connected with the sales department of the Chicago Pneumatic Tool Company, and previous to that was four years with Fairbanks, Morse & Company. Mr. Mahoney was formerly chief clerk to the purchasing agent of the T. St. L. & W. Ry. Mr. Benedict has been in the railroad business ten years and for the past five or six years has been connected with the Chicago Pneumatic Tool Company, as manager of the Chicago office and on the road.

CONVENTION EXHIBITS.

Young's Million Dollar Pier afforded splendid facilities for exhibition purposes. The exhibits were greater in number and far better arranged than those of any previous convention. Among the companies having exhibits or having representatives at the convention were the following:

Adams & Westlake Co., Chicago.
Ajax Manufacturing Company, Cleveland, O.
American Balance Valve Co., Jersey Shore, Pa.
American Brake Co., St. Louis, Mo.
American Brake Shoe & Foundry Co., Mahwah, N. J.
American Car & Foundry Co., St. Louis.
American Locomotive Company, New York.
American Nut & Bolt Fastener Company, Pittsburg, Pa.
American Steam Gauge & Valve Mfg. Company, Boston, Mass.
American Steel Foundries and Simplex Railway Appliance Co., Chicago.
American Tool Works Company, Cincinnati, O.
American Vanadium Company, Pittsburg, Pa.
American Water Softener Company, Philadelphia, Pa.
Anchor Packing Company, Philadelphia, Pa.
Baldwin Locomotive Works, Philadelphia, Pa.
Bardons & Oliver, Cleveland, O.
Beardsley & Co., Boston, Mass.
Bettendorf Axle Co., Davenport, Ia.
Bickford Drill & Tool Co., Cincinnati, O.
Bliss Electric Car Lighting Co., Milwaukee, Wis.
Bowser, S. F. & Co., Fort Wayne, Ind.
Brewer Bros. Co., Philadelphia.
Bull Company, I. G., Philadelphia.
Buckeye Steel Castings Co., Columbus, O.
Bush & McCormick, Columbus, O.
Butler Drawbar Attachment Co., Cleveland, O.
Cardwell Mfg. Co., Chicago, Ill.
Carey, Philip, Mfg. Co., Cincinnati, O.
Carter Iron Company.
Celfor Tool Company, Chicago.
Champion Rivet Co., Cleveland, O.
Chicago Car Heating Co., Chicago.
Chicago Pneumatic Tool Co., Chicago.
Cincinnati Machine Tool Co., Cincinnati, O.
Cincinnati Milling Machine Co., Cincinnati, O.
Cincinnati Planer Co., Cincinnati, O.
Cleveland Car Specialty Co., Cleveland, O.
Commonwealth Steel Co., St. Louis.
Davis Solid Truss Brake Beam Co., Wilmington, Del.
Dearborn Drug & Chemical Works, Chicago.
Detroit Lubricator Co., Detroit, Mich.
Dickinson, Paul, Inc., Chicago.
Dill Machine Co., T. C., Philadelphia.
Dixon Crucible Co., Jos., Jersey City, N. J.
Dressel Railway Lamp Works, New York.
Drouve Co., G., Bridgeport, Conn.
Duner Co., Chicago.
Edwards Co., O. M., Syracuse, N. Y.
Electric Storage Battery Co., Philadelphia.
Falls Hollow Staybolt Co., Cuyahoga Falls, O.
Farlow Draft Gear Co., Baltimore, Md.
Flannery Bolt Co., Pittsburg, Pa.
Flexible Compound Co., Philadelphia.
France Packing Co., Tacony, Pa.
Franklin Mfg. Co., Franklin, Pa.
Frost Railway Supply Co., Detroit, Mich.
Fuller Iron & Steel Company, H. A., St. Louis, Mo.
Galena Signal Oil Co., Franklin, Pa.
General Electric Company, Schenectady, N. Y.
General Railway Supply Company, Chicago.
Gisholt Machine Co., Madison, Wis.
Goldschmidt Thermit Company, New York.
Goodwin Car Company, New York.
Gould Coupler Company, New York.
Gruith Folding Vestibule Trap.
Grip Nut Company, Chicago.
Homestead Valve Mfg. Co., Homestead, Pa.
Invisible Roll Screen Co., Brooklyn, N. Y.
Johns-Manville Co., H. W., New York.
Kennicott Water Softener Company, Chicago.
Lancaster Machine & Knife Works, Lancaster, N. J.
Landis Machine Co., Waynesboro, Pa.
Landis Tool Company, Waynesboro, Pa.
Lawrenceville Bronze Company, Pittsburg, Pa.
Locomotive Appliance Company, Chicago.
Lodge & Shipley Machine Tool Co., Cincinnati.
Lovc Brake Shoe Co., Chicago.
Lucas Machine Tool Co., Cleveland, O.
McConway & Torley Co., Pittsburg, Pa.
McCord & Co., Chicago.
Maltby, Geo. B., Cleveland.
Marshall & Huschart Machinery Co., Chicago.
Michigan Lubricator Co., Detroit, Mich.
Murphy & Company, Christopher, Chicago, Ill.
Nathan Manufacturing Company, New York.
National Acme Manufacturing Company, Cleveland, O.
National Aniline & Chemical Co., Philadelphia.
National Boiler Washing Co., Chicago.
National Malleable Castings Co., Cleveland, O.
National Roofing Company, Tonawanda, N. Y.
National Tube Company, Pittsburg, Pa.
Niles-Bement-Pond Company, New York.
Norton Company, Worcester, Mass.
Parkesburg Iron Company, Parkesburg, Pa.
Pittsburgh Emery Wheel Company, Pittsburg, Pa.
Pittsburg Equipment Co., Pittsburg, Pa.
Pressed Steel Car Company, Pittsburg.
Railway Materials Company, Chicago.
Ralston Steel Car Co., Columbus, O.
Restein Clement Co., Philadelphia.
Ritter Folding Door Co., Cincinnati.
Rubberset Brush Co., Newark, N. J.
Ryerson, Joseph T., & Son, Chicago.
Safety Car Heating & Lighting Co., New York.
St. Louis Surfacer & Paint Co., St. Louis, Mo.
Scullin-Gallagher Iron & Steel Co., St. Louis.
Scully Steel & Iron Co., Chicago.
Sellers, Wm., & Co., Inc., Philadelphia.
Smith Company, Chas. G., Pittsburg, Pa.
Smith Co., Wm. J., New Haven, Conn.
Springfield Machine Tool Co., Springfield, O.
Standard Car Truck Co., Chicago.
Standard Coupler Company, New York.
Standard Steel Car Company, Pittsburg, Pa.
Standard Steel Works Co., Philadelphia.
Sterling Steel Foundry Co., Pittsburg, Pa.
Steever Elv. & Mfg. Co., Lebanon, Pa.
Symington Co., T. H., Baltimore, Md.
Tindel-Morris Co., Eddystone, Pa.
Underwood, H. B., & Co., Philadelphia.
Vanadium Sales Company of America.
Ward Equipment Co., New York.
Watson-Stillman Co., New York.
Waugh Draft Gear Co., Chicago, Ill.
Western Railway Equipment Co., St. Louis.
Western Tool & Mfg. Co., Springfield, Ohio.
Westinghouse Companies, Pittsburg, Pa.
Wood, G. S., Chicago.
Whiting Fdy. Equipment Co., Harvey, Ill.
Wright Wrench Co., 3011 Chestnut St., Philadelphia.

COMPOUND, SUPERHEATED STEAM, MOTOR CAR

CHICAGO, ROCK ISLAND & PACIFIC RAILROAD.

The Schenectady Works of the American Locomotive Company has recently completed a steam motor car * for the Chicago, Rock Island & Pacific Railroad. The motive power of this car consists of a 250 h.p., two-cylinder compound steam engine having cylinders 9¾ and 14½ x 12 in. operated by superheated steam of 250 lbs. pressure generated in a horizontal return tubular boiler. The cylinders drive a pair of 38 inch wheels, forming the trailing wheels of the leading or motor truck. The car is of steel construction with interior finish of wood, is 55 ft. 9 in. total length, weighs 100,000 lbs. in working order and has a capacity of 40 passengers in addition to a good size baggage compartment. Test runs have shown it to be capable of speeds of 60 miles per hour. The distribution of weights is such as to give 38,300 lbs. on the trailing truck, and 61,700 lbs. on the motor truck, of which 32,400 lbs. is on the driving wheels. The theoretical tractive effort, working compound, is 4,300 lbs.

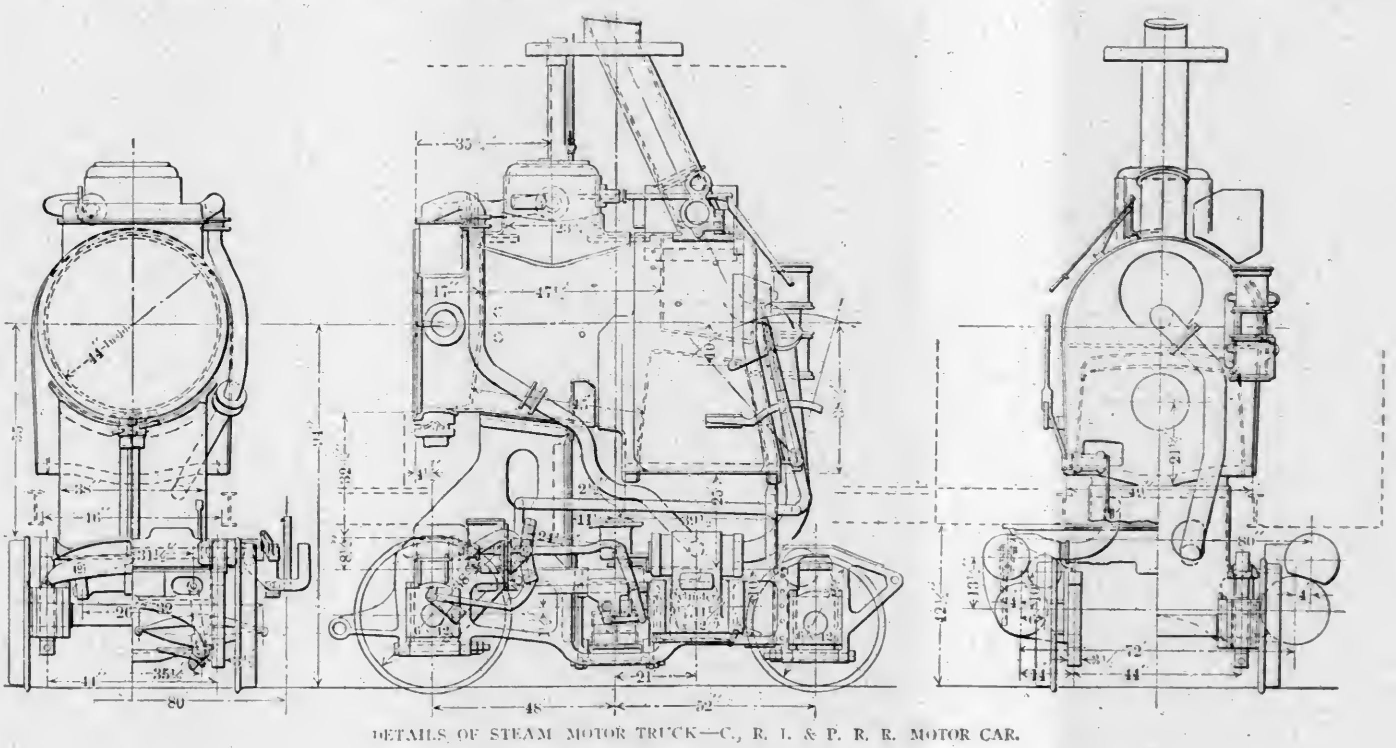
STEAM MOTOR CAR—CHICAGO, ROCK ISLAND AND PACIFIC RAILROAD.

The car body was built at the Wilmington Works of the American Car & Foundry Co., and the primary object in the design was to make it as light as possible; consistent with the proper degree of strength for a car operating singly. With this in mind, a type of construction which employs truss rods for reinforcing the side sills was adopted. The framing and exterior sheathing are of steel and the interior finish is of mahogany.

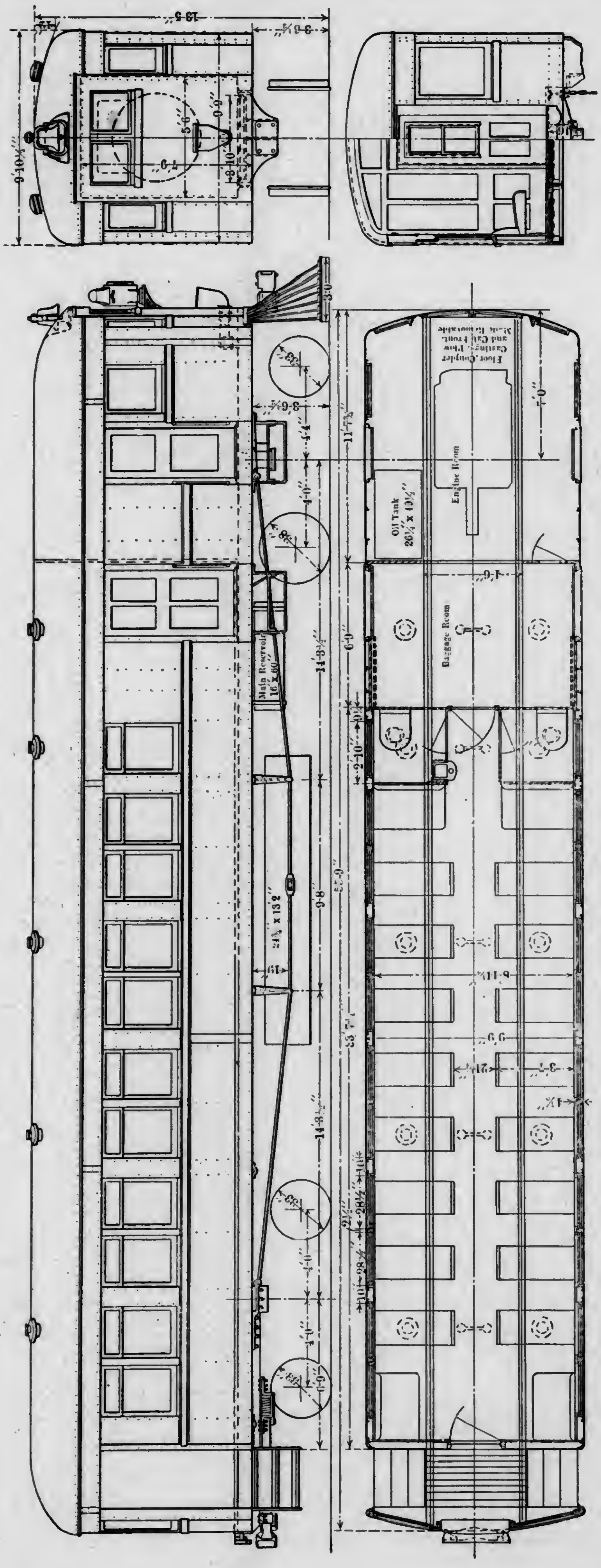
The underframe consists of two 8 in. I beams forming center sills and 6 x 4 x ½ in. steel angles reinforced by 1½ in. truss rods forming side sills. The side sills are further reinforced by another 6 x 4 x ½ in. angle for a distance of 20 ft. at the front end. The end sills are 8 in. steel channels and a number of steel angles are secured between the center and side sills between the bolsters. These cross braces, in addition to forming stiffeners, also serve as floor supports. The side posts are made up of angles riveted to the side sills and the side plates. The plates are in one continuous piece for the entire length of the car, being bent to form the proper contour at the end. The carlins are steel channels, continuous between side plates, bent to conform to the contour of the elliptical roof.

The bolster at the trailing end of the car is of the built up type, but that at the motor end is of cast steel made in three sections and secured in such a manner that the middle section may be readily removed and permit the motor, with its superimposed boiler, to be drawn out from the end of the car. The end sill and the center section of the front end framing of the car body, as well as the floor ahead of the boiler, are also made removable for the same purpose.

* For description of other steam motor cars see this Journal 1906, pp. 291 and 331 (C. P. R.), 1907, pp. 111 (Ganz, C. R. I. & P.); 312 (Ganz, Erie); 391 (Intercolonial); 115 (Ganz, Intercolonial), and 317.



DETAILS OF STEAM MOTOR TRUCK—C., R. I. & P. R. R. MOTOR CAR.



PLAN AND ELEVATIONS OF STEAM MOTOR CAR BODY—CHICAGO, ROCK ISLAND AND PACIFIC R. R.

The boiler is a very interesting design, being altogether different from anything that has previously been applied to a car of this type in this country. The conditions require that the largest amount of heating surface possible shall be obtained in the very small space allowed and, since a fire tube type of boiler was desired, the return tubular type was decided upon. It consists of a fire box 33⅛ in. long by 43¼ in. wide, which is fitted with fire brick and arranged for burning oil; 214 1¼-in. tubes, 3 ft. 9 in. long, extend to the combustion chamber, and an equal number of return tubes of the same diameter and 3 ft. 11½ in. long terminate in the smoke box directly above the fire box. The barrel of the boiler, which is in one sheet 61⅜ in. long, measures 49 in. in diameter at the fire box end and 44 in. at the combustion chamber end. The total amount of heating surface is 624.4 sq. ft., of which 527.8 sq. ft. are in the tubes, 37.6 sq. ft. in the fire box, and 59 sq. ft. in the combustion chamber. The arrangement of the inclined smoke stack and location of the dome, etc., is clearly shown in the illustration.

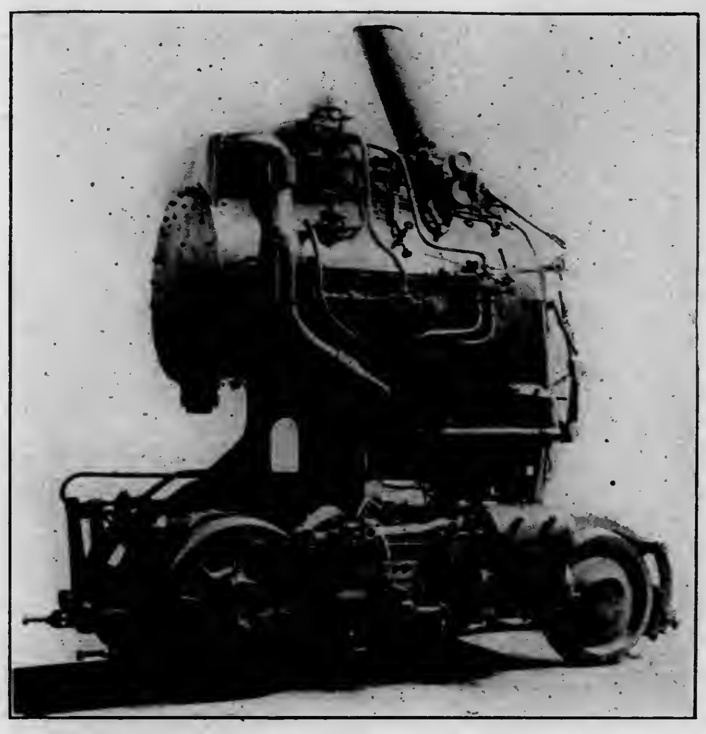
A smoke box type of superheater is located in the combustion chamber, where the temperature of the gases is very high. This superheater consists of a header, divided transversely into two compartments by means of a vertical partition, and 16 superheater tubes, bent into the shape of a double loop and extending down into the combustion chamber. This header is bolted to a cast steel saddle casting, which is secured on the top of the boiler. The steam passes from the dome through a short dry pipe into the saturated steam compartment in the header and through the superheater loops into the superheated compartment and then through the steam pipe to the high pressure steam chest. The boiler is securely fastened to the motor truck frames, thus eliminating the necessity of flexible steam joints.

The engine is of the two-cylinder, cross compound, type, using the Mellin system of compounding, the intercepting valve being located in the high pressure cylinder casting. The high pressure cylinder, which is 9¼ x 12 in., is located on the right side of the truck, and the low pressure cylinder, 14½ x 12 in., on the left side. Both cylinders are equipped with piston valves actuated by Walschaert valve gear. The cylinders, with their valve chamber, are in separate castings, and are bolted to the side frames of the motor truck, the centers being 69 in. ahead of the center of the driving wheels. Connection to the drivers is made through a small cross head, having a single bar guide, and short main rods located outside the frames.

The motor truck is of the four-wheel, swing bolster, type, having cast steel side frames 3½ in. wide, which are rigidly tied together by cast steel transoms and cross ties. The bolster is carried on double elliptic springs. The weight on the rear, or driving journals, is carried by a semi-elliptic spring suspended between two cross equalizers, the ends of which rest on the journal boxes and the weight on the forward journals is carried by coil springs, one on top of each journal. In this manner a three-point suspension truck is obtained. The boiler is supported from the truck by plate braces, both transverse and longitudinal, which are stiffened where necessary.

The trailer truck is of the four-wheel, two-bar equalizer type, having swinging bolsters of the built up type, and has 34 in. wheels and 4¼ x 8 in. journals. Both the motor and trailer trucks are equipped with New York Air Brake Co.'s brakes, air, however, being obtained from an 8 in. Westinghouse air pump. The New York air signal equipment and Gold steam heating equipment have been applied. The lighting is by oil lamps.

The oil for fuel is carried in a tank located in the engine room, which has a capacity of 100 gallons. A water supply of 1,000 gallons is carried in three tanks suspended beneath the



SIDE VIEW OF STEAM MOTOR TRUCK.

floor of the car. The general dimensions and weights of this car are as follows:

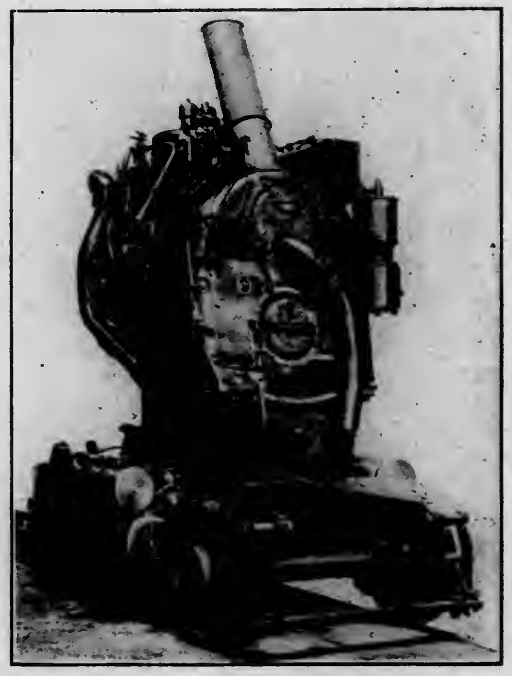
Total weight	100,000 lbs.
Weight on leading truck	61,700 lbs.
Weight on drivers	32,400 lbs.
Weight on leading wheels	29,300 lbs.
Weight on rear truck	38.300 lbs.
Total wheel base	45 ft. 10 in.
Distance between truck centers	38 ft. 3 in.
Wheel base, driving truck	8 ft. 4 in.
Length of car body over sheathing	52 ft. 0 in.
Length of car body over platform	55 ft. 9 in.
ENGINE.	
Diameter of cylinders, H. P.	9¼ lb.
Diameter of cylinders, L. P.	14½ in.
Stroke	12 in.
Valves	Piston
Valve gear	Walschaert
WHEELS.	
Driving, number	2
Driving, diameter	38 in.
Leading, diameter	33 in.
Rear truck, diameter	34 in.
Journals, driving	6 x 12 in.
Journals, trailing truck	4¼ x 8 in.
BOILER.	
Type	Horizontal return tubular
Working pressure	250 lbs.
Outside diameter at combustion chamber	44 in.
Fire box, length	33⅛ in.
Fire box, width	43¼ in.
Tubes, diameter	1¼ in.
Tubes, number and length	214—3 ft. 9 in. 214—3 ft. 11½ in.
Heating surface, tubes	527.8 sq. ft.
Heating surface, fire box	37.6 sq. ft.
Heating surface, combustion chamber	59 sq. ft.
Heating surface, total	624.4 sq. ft.

AVAILABLE WATER POWERS IN UNITED STATES.

In the aggregate the available water powers of the nation greatly exceed the present power requirements, but unless there is some curtailment in the rate of our development, our water-power resources will not of themselves solve the problem of our future supply of power. The power of Niagara Falls has been estimated, by Prof. W. C. Unwin, at 7,000,000 horse-power. A partial estimate of the water powers of the upper Mississippi river and tributaries places the available water power at about 2,000,000 horse-power. The southern Appalachian regions can furnish a minimum of nearly 3,000,000 horse-power. Both of these estimates can be greatly increased by including the use of regulation reservoirs and auxiliary steam plants. The water powers of New England are more fully developed than elsewhere in the country, though much remains yet to be done. In the Rocky mountains and the far West there are immense water-power possibilities; in the State of Washington alone there are 3,000,000 horse-power available. It is probable that the water power in the United States exceeds 30,000,000 horse-power, and under certain assumptions as to storage reservoirs this amount can be increased to about 150,000,000 horse-power or possibly more.

Using the smaller figure of 30,000,000 horse-power as an illustration, to develop an equal amount of energy in our most modern steam-electric plants, would require the burning of nearly 225,000,000 tons of coal per annum, and in the average steam-engine plant, as now existing, more than 600,000,000 tons of coal, or 50 per cent. in excess of the total coal production of the country in 1906. At an average price of $3 per ton it would require the consumption of coal costing $1,800,000,000 to produce an equivalent power in steam plants of the present general type.

Using the data furnished by the census returns of 1900, 1902 and 1905 as a basis and applying the prevailing rate of increase in the industries included in these reports, and adding an equivalent amount for the steam railroads, it is estimated that the total installed capacity of prime movers in all our land industries for 1908 approximates 30,000,000 horse-power.

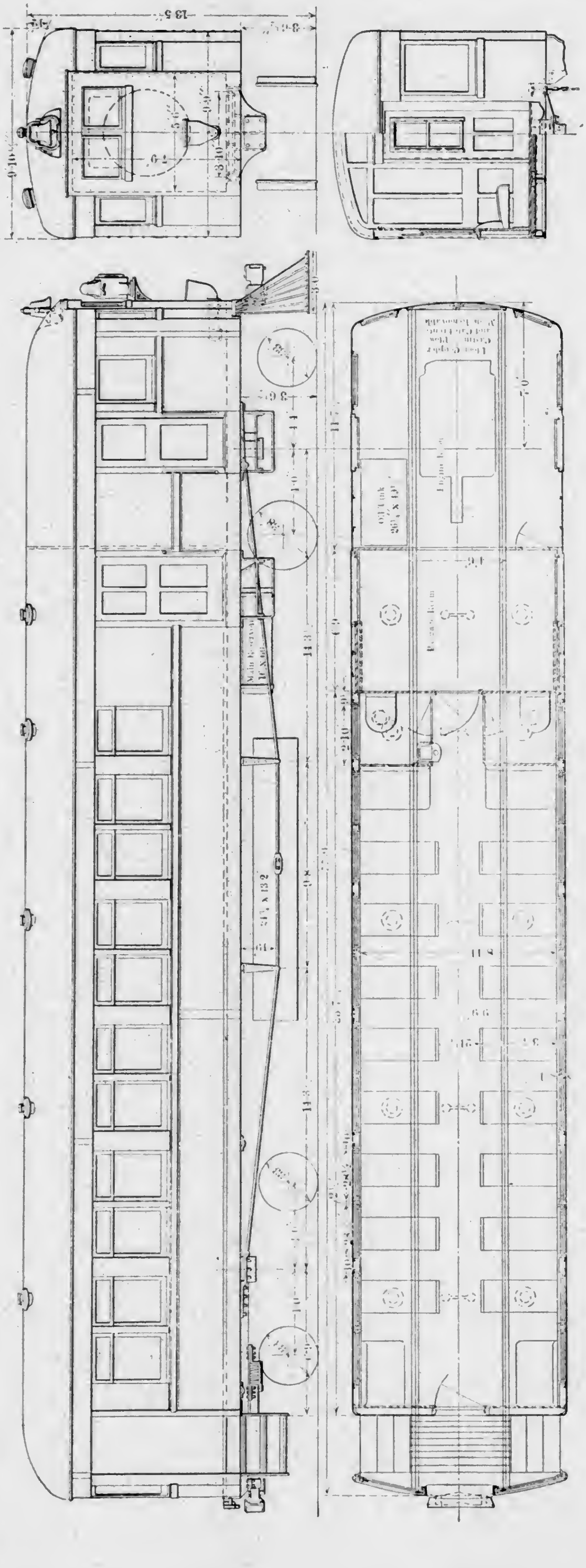


FRONT VIEW OF STEAM MOTOR TRUCK.

The average load on steam and other engines is much less than their rated capacity and, owing to the overlapping of loads, it is probable that the total average load does not exceed one-third or one-quarter of this amount.—*H. St. Clair Putnam in an Address before the Conference on the Conservation of Natural Resources.*

The Largest Belt.—What is believed to be the largest belt in the world was recently installed in the Dempster sawmill at Tacoma, Wash. The hides of 225 steers were needed for making it. Only the centers of the hides were used and each of these was stretched for weeks to insure uniform strength in all parts of the proposed belt. The belt is 114 feet long, 8 feet wide and three-ply thick and weighs something over 2,500 pounds. The best quality of cement was used and the places where the hides overlap welded by the weight of a hydraulic press bearing 250 pounds pressure to the square foot.—*Power.*

Red lead and glycerin when mixed make an excellent material for making tight joints on non-metallic materials.—*Brass World.*



PLAN AND ELEVATIONS OF STEAM MOTOR CAR BODY—CHICAGO, ROCK ISLAND AND PACIFIC R. R.

The boiler is a very interesting design, being altogether different from anything that has previously been applied to a car of this type in this country. The conditions require that the largest amount of heating surface possible shall be obtained in the very small space allowed and, since a fire tube type of boiler was desired, the return tubular type was decided upon. It consists of a fire box 33⅛ in. long by 43¾ in. wide, which is fitted with fire brick and arranged for burning oil; 214 1¼-in. tubes, 3 ft. 9 in. long, extend to the combustion chamber, and an equal number of return tubes of the same diameter and 3 ft. 11½ in. long terminate in the smoke box directly above the fire box. The barrel of the boiler, which is in one sheet 61⅜ in. long, measures 40 in. in diameter at the fire box end and 44 in. at the combustion chamber end. The total amount of heating surface is 624.4 sq. ft., of which 527.8 sq. ft. are in the tubes, 37.6 sq. ft. in the fire box, and 59 sq. ft. in the combustion chamber. The arrangement of the inclined smoke stack and location of the dome, etc., is clearly shown in the illustration.

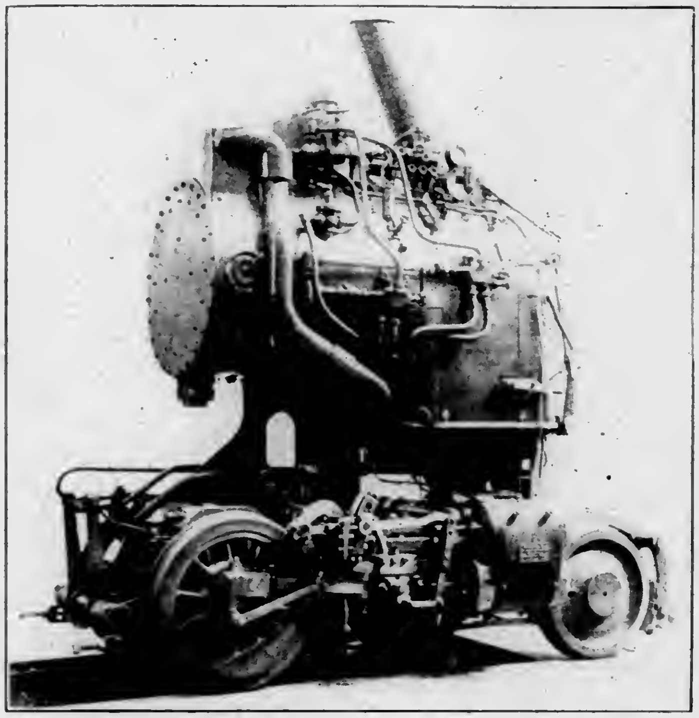
A smoke box type of superheater is located in the combustion chamber, where the temperature of the gases is very high. This superheater consists of a header, divided transversely into two compartments by means of a vertical partition, and 16 superheater tubes, bent into the shape of a double loop and extending down into the combustion chamber. This header is bolted to a cast steel saddle casting, which is secured on the top of the boiler. The steam passes from the dome through a short dry pipe into the saturated steam compartment in the header and through the superheater loops into the superheated compartment and then through the steam pipe to the high pressure steam chest. The boiler is securely fastened to the motor truck frames, thus eliminating the necessity of flexible steam joints.

The engine is of the two-cylinder, cross compound, type, using the Mellin system of compounding, the intercepting valve being located in the high pressure cylinder casting. The high pressure cylinder, which is 9¼ x 12 in., is located on the right side of the truck, and the low pressure cylinder, 14½ x 12 in., on the left side. Both cylinders are equipped with piston valves actuated by Walschaert valve gear. The cylinders, with their valve chamber, are in separate castings, and are bolted to the side frames of the motor truck, the centers being 60 in. ahead of the center of the driving wheels. Connection to the drivers is made through a small cross head, having a single bar guide, and short main rods located outside the frames.

The motor truck is of the four wheel, swing bolster, type, having cast steel side frames 3½ in. wide, which are rigidly tied together by cast steel transoms and cross ties. The bolster is carried on double elliptic springs. The weight on the rear, or driving journals, is carried by a semi-elliptic spring suspended between two cross equalizers, the ends of which rest on the journal boxes and the weight on the forward journals is carried by coil springs, one on top of each journal. In this manner a three-point suspension truck is obtained. The boiler is supported from the truck by plate braces, both transverse and longitudinal, which are stiffened where necessary.

The trailer truck is of the four-wheel, two-bar equalizer type, having swinging bolsters of the built up type, and has 34 in. wheels and 4¼ x 8 in. journals. Both the motor and trailer trucks are equipped with New York Air Brake Co.'s brakes, air, however, being obtained from an 8 in. Westinghouse air pump. The New York air signal equipment and Gold steam heating equipment have been applied. The lighting is by oil lamps.

The oil for fuel is carried in a tank located in the engine room, which has a capacity of 100 gallons. A water supply of 1,000 gallons is carried in three tanks suspended beneath the



SIDE VIEW OF STEAM MOTOR TRUCK.

floor of the car. The general dimensions and weights of this car are as follows:

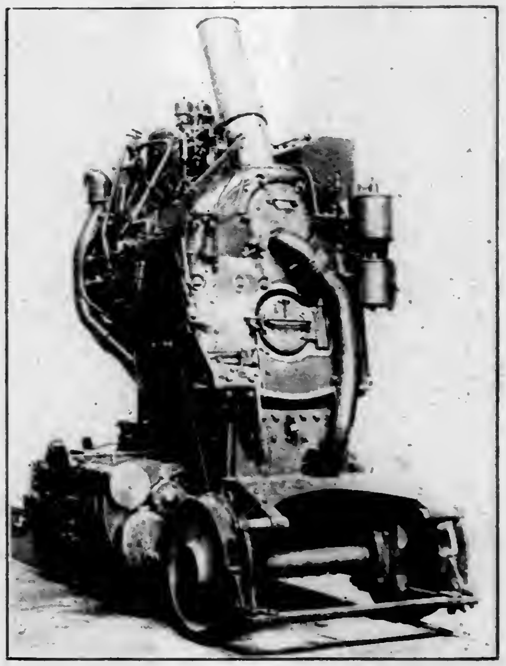
Total weight	100,000 lbs.
Weight on leading truck	61,700 lbs.
Weight on drivers	32,400 lbs.
Weight on leading wheels	29,300 lbs.
Weight on rear truck	38,300 lbs.
Total wheel base	45 ft. 10 in.
Distance between truck centers	38 ft. 3 in.
Wheel base, driving truck	8 ft. 4 in.
Length of car body over sheathing	52 ft. 0 in.
Length of car body over platform	55 ft. 9 in.
ENGINE.	
Diameter of cylinders, H. P.	9¾ lb.
Diameter of cylinders, L. P.	11½ in.
Stroke	12 in.
Valves	Piston
Valve gear	Walschaert
WHEELS.	
Driving, number	2
Driving, diameter	38 in.
Leading, diameter	33 in.
Rear truck, diameter	34 in.
Journals, driving	6 x 12 in.
Journals, trailing truck	4¼ x 8 in.
BOILER.	
Type	Horizontal return tubular
Working pressure	250 lbs.
Outside diameter at combustion chamber	44 in.
Fire box, length	33⅝ in.
Fire box, width	13¼ in.
Tubes, diameter	1¼ in.
Tubes, number and length	214 3 ft. 9 in.
	214 3 ft. 11½ in.
Heating surface, tubes	527.8 sq. ft.
Heating surface, fire box	37.6 sq. ft.
Heating surface, combustion chamber	59 sq. ft.
Heating surface, total	624.1 sq. ft.

AVAILABLE WATER POWERS IN UNITED STATES.

In the aggregate the available water powers of the nation greatly exceed the present power requirements, but unless there is some curtailment in the rate of our development, our water-power resources will not of themselves solve the problem of our future supply of power. The power of Niagara Falls has been estimated, by Prof. W. C. Unwin, at 7,000,000 horse power. A partial estimate of the water powers of the upper Mississippi river and tributaries places the available water power at about 2,000,000 horse power. The southern Appalachian regions can furnish a minimum of nearly 3,000,000 horse-power. Both of these estimates can be greatly increased by including the use of regulation reservoirs and auxiliary steam plants. The water powers of New England are more fully developed than elsewhere in the country, though much remains yet to be done. In the Rocky mountains and the far West there are immense water-power possibilities; in the State of Washington alone there are 3,000,000 horse-power available. It is probable that the water power in the United States exceeds 30,000,000 horse-power, and under certain assumptions as to storage reservoirs this amount can be increased to about 150,000,000 horse power or possibly more.

Using the smaller figure of 30,000,000 horse-power as an illustration, to develop an equal amount of energy in our most modern steam electric plants, would require the burning of nearly 225,000,000 tons of coal per annum; and in the average steam engine plant, as now existing, more than 600,000,000 tons of coal, or 50 per cent. in excess of the total coal production of the country in 1906. At an average price of $3 per ton it would require the consumption of coal costing $1,800,000,000 to produce an equivalent power in steam plants of the present general type.

Using the data furnished by the census returns of 1900, 1902 and 1905 as a basis and applying the prevailing rate of increase in the industries included in these reports, and adding an equivalent amount for the steam railroads, it is estimated that the total installed capacity of prime movers in all our land industries for 1908 approximates 30,000,000 horse-power.

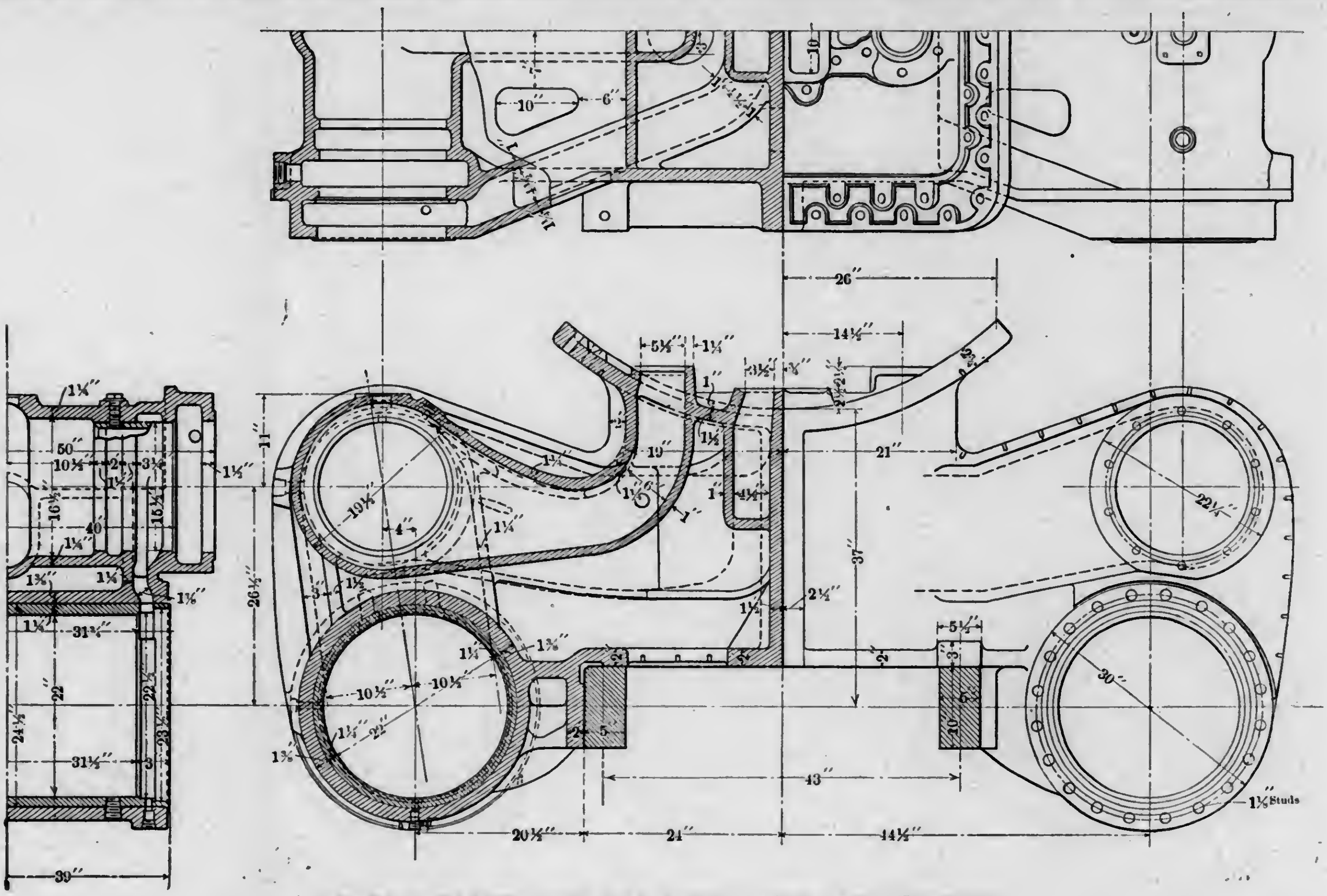


FRONT VIEW OF STEAM MOTOR TRUCK.

The average load on steam and other engines is much less than their rated capacity and, owing to the overlapping of loads, it is probable that the total average load does not exceed one-third or one-quarter of this amount.—*H. St. Clair Putnam in an Address before the Conference on the Conservation of Natural Resources.*

The Largest Belt.—What is believed to be the largest belt in the world was recently installed in the Dempster sawmill at Tacoma, Wash. The hides of 225 steers were needed for making it. Only the centers of the hides were used and each of these was stretched for weeks to insure uniform strength in all parts of the proposed belt. The belt is 114 feet long, 8 feet wide and three-ply thick and weighs something over 2,500 pounds. The best quality of cement was used and the places where the hides overlap welded by the weight of a hydraulic press bearing 250 pounds pressure to the square foot.—*Power.*

Red lead and glycerin when mixed make an excellent material for making tight joints on non-metallic materials.—*Brass World.*



DETAILS OF CYLINDERS—NEW YORK CENTRAL PACIFIC TYPE LOCOMOTIVES.

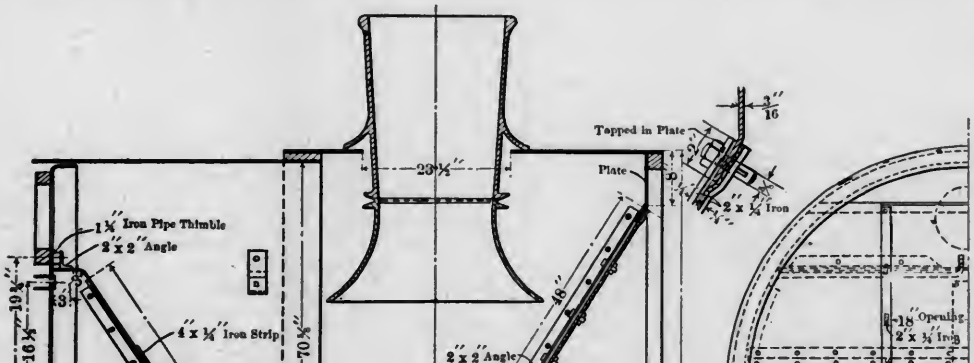
DETAILS OF HEAVY PACIFIC TYPE LOCOMOTIVE.

NEW YORK CENTRAL LINES.

A general description, illustrated with photograph and general elevations, as well as boiler details, of some very powerful Pacific type locomotives, which were recently delivered to the New York Central Lines by the American Locomotive Company, appeared on page 164 of the May, 1908, issue of this journal.

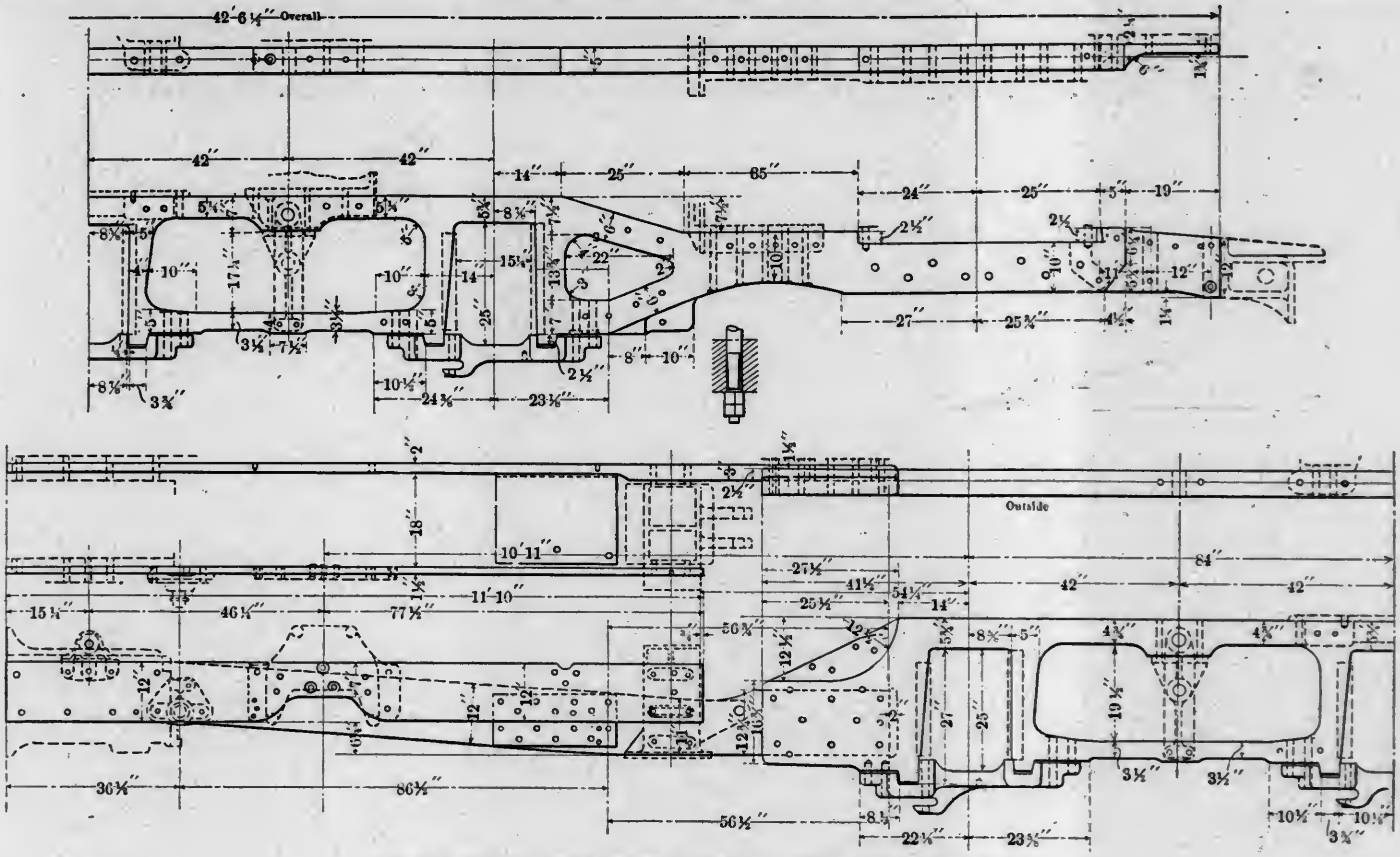
These locomotives can be said to be the heaviest passenger locomotives in regular service in the world, as they are exceeded in total weight only by two experimental engines on the Pennsylvania Railroad. The total weight is 266,000 lbs., of which 171,500 lbs. is on drivers. The tractive effort of 29,200 lbs. is seemingly small for so large a weight on drivers and gives a ratio of adhesion of 5.84. This, however, indicates a most satisfactory condition for passenger locomotives, since it assures the ability to develop full power in starting a heavy train without slipping the drivers.

The boiler measures 72 in. outside diameter at the front ring and is of the conical type, the reducing sheet forming the second ring and increasing the outside diameter to 83 in. at the dome ring. There are 382 2-in. tubes 20 ft. long, which give a heating surface of 3,981.6 sq. ft. The total heating surface of the boiler is 4,209.9 sq. ft. and the grate area is 56.5 sq. ft. Reference can be made to the table on page 165 for the boiler and other ratios.



FRONT END ARRANGEMENT—NEW YORK CENTRAL PACIFIC TYPE LOCOMOTIVES.

The front end arrangement of this boiler is interesting, largely because of the fact that the tube sheet is set 60½ in. back of the center line of the stack. This gives a total length of front end of 96½ in., a figure which was quite common a few years ago when extension front ends were popular, but differs from them in the fact that the stack is at the front instead of at the rear end. The arrangement of the deflector and diaphragm plates is shown in one of the illustrations. It will be seen that a diaphragm plate of 3/16 in. steel extends from the top of the tubes downward at an angle of about 35 degrees to a point 22⅛ in. from the bottom of the ring. From this point flat plates of the same material extend forward to a point just in front of the exhaust nozzle where an adjustable diaphragm apron, projecting vertically downward is provided. The maximum clearance beneath this



FRAME DETAILS—NEW YORK CENTRAL PACIFIC TYPE LOCOMOTIVE.

apron is 14¼ in. from the bottom of the front end and is adjustable. The netting extends diagonally upward from the end of the horizontal sheet, to near the top of the front ring, a section 18 in. wide in the center being removable. The exhaust tip is located just above the horizontal plate and the stack has an inside extension, bringing the choke 12 in. inside of the front end and is equipped with a wide flaring bottom without draft pipes. With a 5½ to 5¾ in. nozzle used on these engines and a distance of 36 in. from tip to choke, the formula derived by Mr. Johnson on page 85 of the March issue indicates the correct diameter of stack to be about 17 in. The stack as applied measures 18 in. diameter at the choke, which checks the formula very nicely, as a difference of one inch, especially if it is larger, is too slight to affect the working.

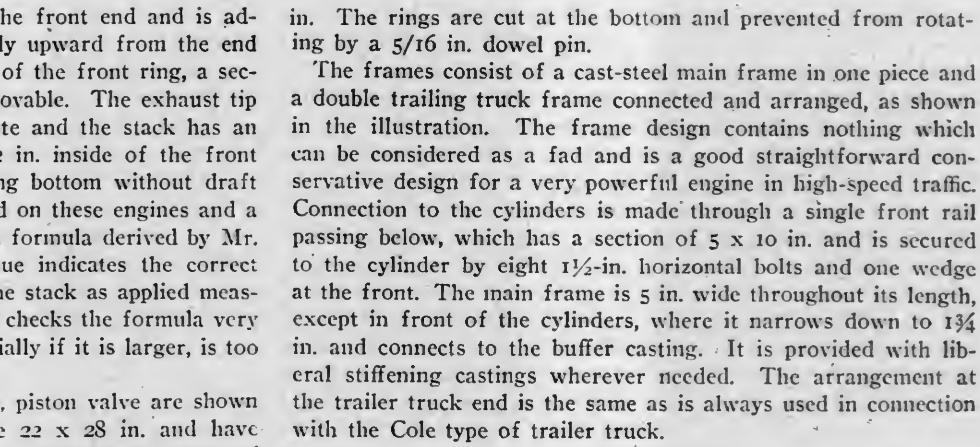
The details of the cylinders and 14-in. piston valve are shown in the illustrations. The cylinders are 22 x 28 in. and have the center of the valve chamber set 4 in. outside the center of the cylinder, so as to allow a direct motion Walschaert valve gear being used. The valves are arranged for central admission and external exhaust and the passages in the cylinder saddle are arranged so that there is always air space between the entering and exhaust steam passages. The area of the passages is liberal and the changes in direction are made with very easy bends.

It will be noticed that the cylinders are fitted with a 1¼-in. bushing, which extends to a bearing with the heads. It is secured in place by two plugs located as shown. The passage from the valve chamber to the cylinder is direct, and there is a dead air space for insulation between the valve chamber and the cylinder proper.

The piston valve consists of a cast-iron body 8 in. outside diameter at the center and cast-steel spiders fitted on either end and held in place by the valve stem. The packing consists of a bull ring pinned to place and turned to give 1/64 in. clearance in the valve chamber bushing, and two packing rings of L shape each presenting a bearing surface of ⅝ in. The rings are cut at the bottom and prevented from rotating by a 5/16 in. dowel pin.

The frames consist of a cast-steel main frame in one piece and a double trailing truck frame connected and arranged, as shown in the illustration. The frame design contains nothing which can be considered as a fad and is a good straightforward conservative design for a very powerful engine in high-speed traffic. Connection to the cylinders is made through a single front rail passing below, which has a section of 5 x 10 in. and is secured to the cylinder by eight 1½-in. horizontal bolts and one wedge at the front. The main frame is 5 in. wide throughout its length, except in front of the cylinders, where it narrows down to 1¾ in. and connects to the buffer casting. It is provided with liberal stiffening castings wherever needed. The arrangement at the trailer truck end is the same as is always used in connection with the Cole type of trailer truck.

Car Lighting in Germany.—Advices received from Germany as to the status of car lighting, are to the effect that electric car lighting has come to a standstill, while the incandescent gas (mantle) lighting is very active, especially with regard to changing over the old fixtures to the incandescent system. The railroads have satisfied themselves, after long tests, of the value of the incandescent gas system, and are now changing over their cars, at the rate of between 500 and 600 lamps per day.



FOURTEEN-INCH PISTON VALVE—NEW YORK CENTRAL LINES.

LOCOMOTIVE SMOKESTACKS.

By W. E. Johnston.

A reply to the criticism of the equation $D = .49 \sqrt{L}$ for smokestacks by Mr. H. R. Stafford on page 184 of the May issue may be divided into two parts:

1. Proof of the accuracy of the calculations and correctness and comparability of the tests on which it is based.
2. Discussion of the possibility of applying the formula in regular practice.

Fig. 1 indicates fairly, I think, why the Master Mechanics' formula is not satisfactory in a great many instances. It is evident in this case that the best size for the stack is the same for smokeboxes Nos. 1, 2 and 3 without regard to their diameter or location. The nozzle and the stack constitute the draft inducing elements and their correct relative proportions are essential. The smokebox serves only as a chamber to enclose these elements and does not affect "D" except by affecting "L."

Limitations of total height, necessary area under the diaphragm or other considerations may vary "L" and consequently "D," and the diameter of the smokebox is no more important than a number of other factors and much less important than some.

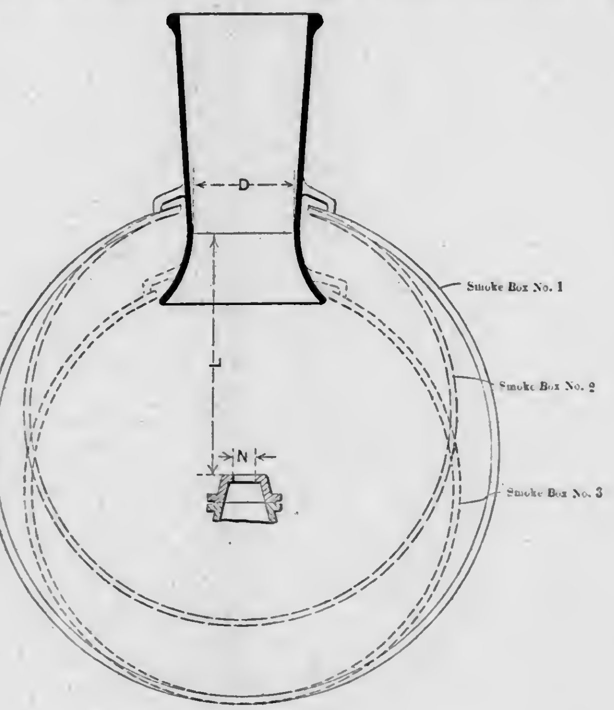


FIG. 1.

Mr. Stafford is in error in stating that the tests of 1903 were made with draft pipes. These tests were made with the plain nozzle and stack and the results are comparable with those made in 1906, except for the difference in the shape of the nozzles as referred to in my original article (page 85, March issue). A correct equation must therefore check with the tests of both 1903 and 1906 and also reasonably closely with those of 1896, allowing for the effect of the draft pipes in the 1896 tests only.

The Master Mechanics' formula was not affected by their conception of the action of the jet in the stack, but was based on the stacks which gave the highest vacuums with given back-pressures. The values for the best stacks for the engines tested as given in their reports are as nearly correct as can possibly be secured, and the error in their formula lies in basing it on a factor which does not control, and only indirectly affects, the stack diameter. Whether, in fact, the jet filled the stack or not, or whether or not the Master Mechanics' committee thought it did are alike immaterial to this discussion. Their formula and the one I have proposed are both based on the results of the tests and are therefore free from any error due to a wrong conception of the action of the jet in producing the vacuum.

The difficulty of providing stacks of proper diameter for given nozzles cannot be considered in deriving a formula to show what the correct diameter should be. Natural laws are not affected by the convenience of their application. This being the case, the important problem is to determine the natural laws and then follow them as closely as conditions will permit. No consideration whatever was given to anything but accuracy in deriving the formula $D = .49\, N \sqrt{L}$, and while I have no positive theoretical proof of its correctness, it agrees very closely with all the comparable results of the tests of 1896, 1903 and 1906 on plain nozzles and stacks through the whole range of the variations of "D" and "L." The area of the 5 11/16" nozzle used in 1906 was about 80 per cent. greater than that of the 4¼" nozzle used in 1903. These tests therefore cover nearly the entire range of variation usually met with in practice of all three of the variables in the equation. If it is admitted that the factors "N" and "L" are the proper ones for determining "D," the equation $D = .49\, N \sqrt{L}$ has as great a weight of good evidence behind it as most empirical formulas, and being based on such accurate and extensive tests may be relied on to give good results.

As the tests of 1903 were made without draft pipes, Mr. Stafford's formula $D = (d + \frac{A}{6})\, 1.4$ must check reasonably close with the results or stand convicted of inaccuracy. Even if draft pipes had been used the allowable variation from the best values could not be very great. Table I shows both equations compared with best results for taper stacks as given in the Master Mechanics' Report. (See page 303 of the August, 1903, issue of this journal.)

TABLE I.

"L" or "A"	$D = (d + \frac{A}{6})1.4$	$D = .49\, N \sqrt{L}$	M.M's table. Best results.
65"	21.1	16.7	16.7
60"	19.9	16.1	15.9
55"	18.8	15.4	15.3
50"	17.6	14.7	14.3
45"	16.4	13.9	13.5
40"	15.3	13.2	12.7
35"	14.1	12.4	11.9
30"	12.9	11.4	11.1
25"	11.8	10.4	10.3
20"	10.6	9.4	9.5

D = Diameter of choke of stack.
L = A = Distance nozzle to choke.
N = d = Diameter of nozzle = 4¼".

This shows conclusively that the formula $D = (d + \frac{A}{6})\, 1.4$ does not contain the correct functions of the variables "d" and "A." I examined a number of expressions of this nature in my preliminary investigation and was forced to the conclusion that no rectilinear function of "L" or "A" would give correct results. I have examined some results of tests on nozzles for steam turbines and for injectors, endeavoring to secure data for a theoretical investigation of the action of the exhaust jet in producing draft. In some of these in which low pressure steam was used discharging into the atmosphere, I noted several peculiar phenomena. The most important probably in its application to locomotive practice is the fact that with certain forms of nozzles the static pressure in the jet in the nozzle dropped considerably below that of the atmosphere, the pressure rising to atmospheric approaching the outlet of the nozzle. Fig. 2, nozzle No. 1 and the diagram above show about what variations of pressure and velocity may be obtained. The maximum velocity and the minimum pressure occur at the same point. Obviously, if the side walls of the nozzle are removed as shown in Fig. 2, nozzle No. 2, at a point where the pressure is lower than atmospheric, the air will be drawn into the jet, as indicated by the arrows, by the difference in static pressure. The steam will be carried by its momentum past the opening, and with its mixture of air out through the remainder of the nozzle.

If the opening in the side of the nozzle be enclosed in a tight box, evidently the pressure in the box will be reduced to that in the jet. To produce a locomotive "front end" then, we need

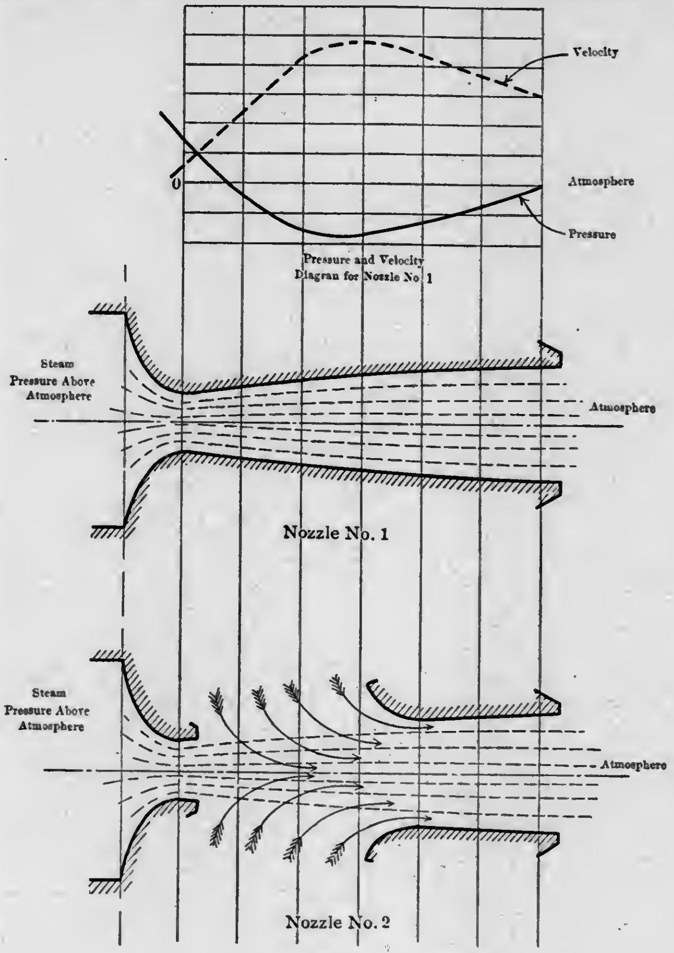


FIG. 2.

only to increase the size of the apparatus suitably and attach it to the front end of a locomotive boiler, the stack and nozzle together forming a long nozzle with the sides cut out similar to nozzle No. 2 in Fig. 2.

No other action is so positive and powerful in producing a rapid flow of gases as a difference of pressure and I am satisfied that it is this reduction of pressure in the jet that draws the gases into it. This is supported by the fact that the gases are mixed entirely through the jet, and explains why the double nozzle and other forms of multiple nozzles do not give results superior to the single nozzle—and also why the nozzle which gave the least spread and greatest velocity to the jet gave the best vacuum as noted by the Master Mechanics' Committee in 1896, the greatest velocity and the minimum pressure in the jet occurring at the same point and being due to the same cause.

In going over the results of the 1896 tests, I found that the amount of steam exhausted as calculated from the area of the jet a short distance above the tip and the velocity as given could be made to check with the measured amount only by the assumption that the pressure in the jet was considerably less than atmospheric.

The velocity of the jet in the 1896 tests was determined by measuring the pressure in tubes with their ends pointed against the jet and the edge of the jet was assumed to be at a point where the manometer connected to the pipe showed neither pressure nor a vacuum. This was not exactly correct, as the point at which the manometer indicated zero was that at which the pressure due to the velocity of the jet was equal to the difference between the pressure of the atmosphere and the static pressure at the tip of the pipe. The jet, therefore, was larger and had greater velocity than shown in the Master Mechanics' report, and any deductions as to the best diameter of stack based on the apparent spread of the jet as shown would also be inaccurate.

In Figs. 3 and 4 I have plotted the curve $D = .49\ N\ \sqrt{L}$ and the best values for "D" taken from Tables I and II of my original article in the March issue above the nozzles used in the 1903 and 1906 tests to show how closely the curves agree with the best results. The Master Mechanics' values for "D," as given in Table I herewith, would agree more closely with the curve in Fig. 3 than the values plotted, but I preferred to take my values from the tests. As explained previously, the nozzle used in 1903 gives a little less spread to the jet than the one used in 1906 and consequently the best stacks of 1903 all come inside the curve but follow it very closely, the average variation being about ½ in.

It might appear to some that the parabola in Figs. 3 and 4 should fit down into the nozzle and I worked out a formula on this assumption, but could not get it to give satisfactory results.

The taper 2" in 12" for the stack is undoubtedly sufficiently accurate for usual sizes of nozzles and usual distances from nozzle to the middle of the conical portion of the stack.

Differentiating the equation $D = .49\ N\ \sqrt{L}$ we get $\dfrac{dD}{dL} = \dfrac{.49 N}{2\sqrt{L}}$ which is the general expression for the total taper of the parabola.

For $L = 64''$ and $N = 5''$

$$\frac{dD}{dL} = \frac{.49 \times 5}{2\sqrt{64}} = \frac{2.45}{16} = \frac{2}{13}$$

for $L = 49$ and $N = 5$

$$\frac{dD}{dL} = \frac{.49 \times 5}{2\sqrt{49}} = \frac{2.45}{14} = \frac{2}{11.2}$$

This shows that the total taper of the parabola $D = .49\ N\ \sqrt{L}$ for $N = 5$ and between $L = 49''$ and $L = 64''$ is between 2" in 11.2" and 2" in 13", so that it agrees with the experimental results on this point also.

Squaring both sides of the equation and multiplying by $\dfrac{\pi}{4}$ we get $\dfrac{\pi D^2}{4} = \dfrac{\pi}{4}(.49)^2\ N^2\ L$. Now $\dfrac{\pi D^2}{4}$ = the area of the choke of the stack. Therefore, by this formula the area of the choke of the stack is made to increase directly as the distance from the nozzle which also conforms to experimental results on steam turbine and injector nozzles, as described before.

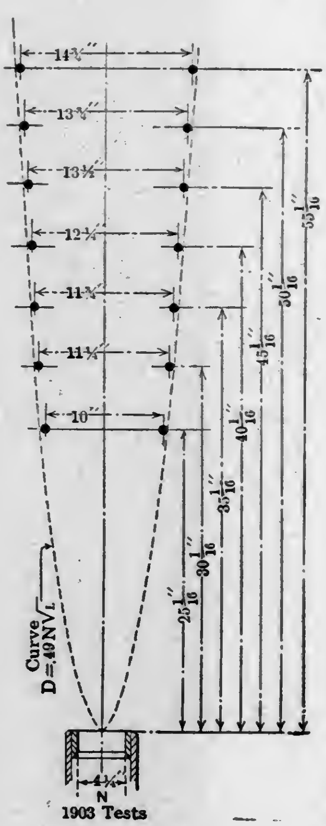


FIG. 3.

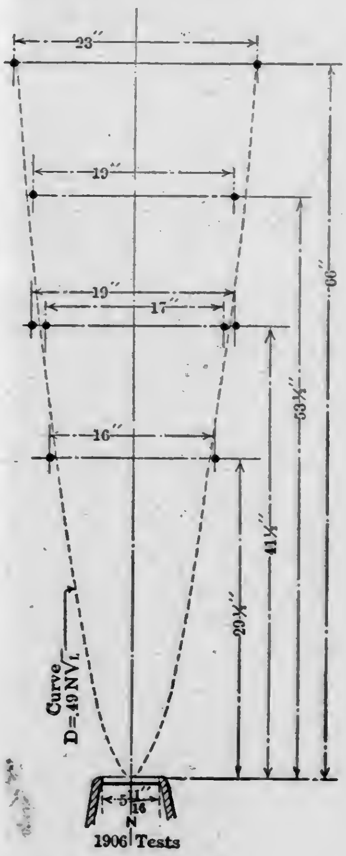


FIG. 4.

Practicability, the second requirement for a smokestack formula, I have endeavored to meet by the stack shown in Fig. 5. There is not sufficient data available at the present time to determine accurately in advance the proper size of nozzle for a new engine, nor will all engines of a class steam well with nozzles of the same size when using different kinds of coal and operating in different kinds of service. The best solution seems to be a stack of which the diameter may be changed readily and with reasonable expense. The stack shown in Fig. 5 consists of:

1.—A base of substantial design, not liable to breakage, not subject to wear and intended to be attached permanently to the smokebox. The turned joint on this base is arranged so that

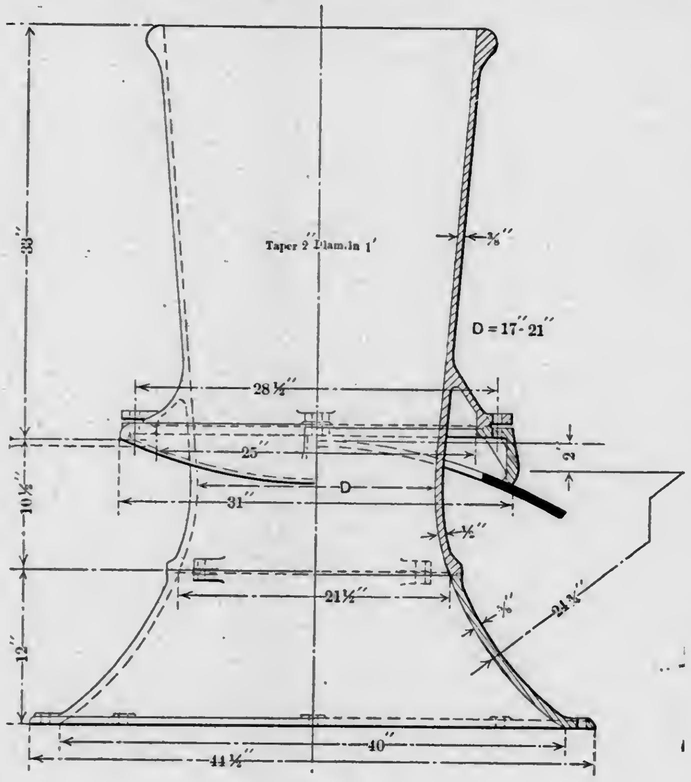


FIG. 5.

barrels of all the sizes which are liable to be required may be attached to it.

2.—A readily changeable barrel of diameter "D" and provided with turned joints for connection to the base and to the extension.

3.—An extension designed in accordance with the Master Mechanics' recommendations.

With this design the necessity for leveling the engine and plumbing the stack when applying a new one is eliminated, this being required only once when the base ring is first applied. The design as shown is suitable for barrels from 17" to 21" in diameter which may be readily interchanged, the turned joints for connection to the base and to the extension being the same for all sizes. A stack removed from one engine on account of its wrong diameter can, of course, be applied to another for which it is suitable, so that the expense for the change would be very small outside of the labor charge.

By a suitable adaptation of this design, three barrel patterns 17", 19" and 21" diameter and variable in length, with one base ring chipped to fit the smokebox or of variable radius and one extension would probably be sufficient for all the larger power on any road and a smaller set for 13", 15" and 17" barrels with a shorter extension would be sufficient for the smaller power. This would require altogether six barrel patterns (lengths to suit), two base rings (radii to suit), and two extensions.

It will be seen from an inspection of the curves in Figs. 2-9 in the article in the March issue, and also from similar curves plotted in the Master Mechanics' 1903 report, that a variation of an inch either way from the best value of "D" does not seriously affect the draft, but that the loss in vacuum increases rapidly with further variations. For this reason a set of stacks varying by 2" could be reasonably expected to give satisfactory results as the greatest variation in stack diameter from the best value could be made 1" or less.

The Master Mechanics' Committee of 1896 recommended that the distance from the nozzle to the choke of a taper stack should be between 40" and 50". This was with a 4¼" nozzle. It is probable that this should be increased for larger nozzles about in proportion to the increase in nozzle diameter. This is corroborated by a comparison of Figs. 9, 6 and 4 in the article in the March issue, the apex of the curves for vacuum being higher for increasing values of "L" up to 66" at least. Figs. 7, 8, 5 and 4 are also fairly comparable, except for the possible effect of the top of the smokebox in Fig. 4, and show better maximum vacuums with increasing values of "L" up to 66". This agrees also with Fig. 10 on page 247 of the Master Mechanics' 1906 Proceedings, sections 9, 8 and 4 and 7, 6, 5 and 4, being comparable in this figure.

The 1896 recommendation makes $L = 10\ N$ to $12\ N$. The 1906 tests indicate that "L" should not be less than 11 N. The formulas $D = .49\ N \sqrt{L}$ and $L = 11\ N$, therefore, represent the best relations between the nozzle and stack, as determined by the Master Mechanics' tests. The matter of determining "N" for new designs is a separate problem and presents an interesting field for further investigation.

Cutting Speeds of High-Speed Tools.—Robert Grimshaw, in a communication to the *American Machinist,* gives the speeds of the new rapid-cutting steels, as stated in a report made to the German Society of Engineers by Prof. Hermann Fischer. The average speeds for roughing cuts in lathes in feet per minute are 50 to 65 for soft cast iron and steel of 85,000 to 100,000 lbs. tensile strength per sq. in.; 40 to 50 for hard cast iron and steel castings, and 65 to 100 for wrought iron and steel of 57,000 to 64,000 lbs. tensile strength per sq. in.

Fuel Economy of Gas Engines.—Though engines of this character antedate the use of the electric motor, their development has been slow, and they occupy a relatively unimportant place as power producers. The ordinary steam engine utilizes not more than 4 or 5 per cent. of the heat energy in coal, and our best modern steam-electric plants show a heat efficiency not exceeding 10 or 12 per cent. With the gas engine and producer gas the heat efficiency can be more than doubled, and still higher efficiency seems probable with higher compression or through the use of other possible improvements. This is a most promising field for development and it is entirely possible that the gas engine may revolutionize our methods of using fuel for the production of power.—*H. St. Clair Putnam before the Conference on the Conservation of the Natural Resources.*

Illuminants, Their Cost and Waste.—We may tabulate the several amounts, given in round numbers, as follows:

ANNUAL VALUE OF ILLUMINANTS.

Candles	$11,000,000
Kerosene	133,000,000
Illuminating gas	60,000,000
Electricity	150,000,000
Acetylene (estimated)	6,000,000
Total	$360,000,000

LIGHTING APPARATUS.

Electrical supplies	$139,000,000
Electric lamps	12,000,000
Fixtures	18,000,000
Lamps and accessories	13,000,000
Total	$182,000,000

Taking 90,000,000 as the present population of the United States, we find that, according to the above figures, the cost of luminants for one year is equivalent to $4 for every man, woman and child. To say that 10 per cent. of the light generated is wasted through misuse and ignorance is certainly a conservative estimate; this gives $36,000,000 as the total amount of loss from this source, or an average of 40 cents per capita for the entire population of this country. Aside from candles and kerosene oil, the waste is probably nearer twice this amount.—*The Illuminating Engineer.*

MASTER MECHANICS'. ASSOCIATION

ABSTRACTS OF COMMITTEE REPORTS AND INDIVIDUAL PAPERS *(Continued from Page 281)*.

Mallet Articulated Compound Steam Locomotives.

Committee—J. E. Muhlfeld, chairman; G. H. Emerson, T. Rumney, F. H. Clark, C. J. Mellin.

The committee appointed to report on this subject submits the following conclusions, which are based on a comparison of the Mallet articulated compound types of steam locomotives now operating on American railways in road and helper freight service with other designs of steam and electric locomotives performing similar work under relative fuel, water and climatic conditions.

First: That for the greatest permissible tonnage and speed per train, on lines of considerable gradient and curvature, the Mallet articulated compound types of steam locomotives, either with or without leading and trailing trucks, and ranging in tractive power of from 55,000 to 125,000 pounds, are relatively lower in first cost and, from performance to date, are more efficient and economical in operation and maintenance per unit of tractive power developed.

Second: That the Mallet articulated compound types of steam locomotives enable a practical improvement in the boiler efficiency by means of greater boiler capacity, increased reserve steam and water storage, larger grate area and fire-box and tube heating surface, prolonged passage of the products of combustion through the boiler, quickened circulation of the water in the boiler, heated feed water and reduced rate of draft and combustion.

Third: That the Mallet articulated compound types of steam locomotives give the practical opportunity to improve the engine efficiency by means of relatively greater tractive effort per pound of adhesive weight and from superheated higher initial, reheated receiver and lower terminal working steam pressure due to the greater ratio of expansion that can be obtained in the cylinders as well as through the use of a large intermediate receiver capacity, which is made possible by the four independent cylinders and their supply steam connections.

Fourth: That the Mallet articulated compound types of steam locomotives should have less depreciation, wear and failure of boiler and machinery through increased reserve capacity, reduced pressure of exhaust steam, more flexible wheel base, subdivision of power and stresses over a greater number of frames, cylinders, pistons, axles, crank pins, rods and auxiliary parts; better balancing of the reciprocating and revolving mechanism, more uniform turning moment and less slipping of driving wheels.

Fifth: That the Mallet articulated types of steam locomotives having relatively less non-adhesive weight per driving wheel and a more uniform turning moment with a reduction in unbalanced pressure at the driving wheel and rail contacts, resulting in maximum adhesion, minimum slipping and a distribution of weight over a short rigid combined with a long flexible wheel base, will materially reduce the bridge, tie and rail strains and the tie and rail wear per unit of tractive power developed.

Sixth: That the Mallet articulated types of steam locomotives either for road or helper freight service can materially increase the capacity of a given piece of track by fewer train movements and less congestion at terminals without increasing the acceleration or running speed above that which is permissible for efficient and economical heavy tonnage train movement, proper working super-elevation of curves, minimum rail wear and the least liability for derailment or accident.

Seventh: That the Mallet articulated compound types of steam locomotives will particularly place the movement of the traffic under the control of fewer persons; lessen the liability for complete disablement and reduce the cost for engine and train crew hire, fuel, water, lubricants, stores, wiping, hostlering and dispatching.

Eighth: That the non-paying weight in motive power and supplies and the retarded movement and stalling of heavy tonnage trains will be minimized by the Mallet articulated types of steam locomotives, especially through exceptionally long tunnels where the permissible reversing of this type of locomotive will not subject the crews to the gases, smoke and heat from the exhaust.

Ninth: That the use of the Mallet articulated compound types of steam locomotives may permit of maintaining or progressively increasing the average gross tonnage per successive train movement between terminal yards to that which, consistent with the balancing of the motive power, distribution of cars and the accumulation of the traffic on the divisions, might give the desired capacity as well as efficiency and economy in the operation of a single piece of trunk-line track and its terminals without making an expenditure on roadway to increase the weight limit or for a reduction of grade, curvature or distance that would otherwise be necessary to accomplish the same result.

Tenth: That for service where it is essential to increase the tons moved per mile per hour per unit of cost by developing greater tractive power in one locomotive than what can be efficiently and economically produced by a consolidation or similar type and where the use of self-contained motive power, proportion of adhesive to total weight, center of gravity, distribution of weight over driving wheels, driving wheel load, flexibility of driving wheel base, and particularly the first cost, fixed charge, operating expense and reliability of service are elements of importance, the use of the Mallet articulated compound types of steam locomotives should receive careful consideration.

RESULTS IN SERVICE.

Baltimore and Ohio Railroad Performance.—The first locomotive put into operation in this country was for the Baltimore & Ohio Railroad, its object being to determine upon the practicability of such a class of motive power to efficiently and economically increase the capacity of a busy, mountainous line in event that might become necessary. The design of the experimental locomotive decided upon was of the Mallet articulated duplex compound steam type, and the construction was completed in April, 1904, after which the locomotive was exhibited at the Louisiana Purchase Exposition, and later put into regular helper freight service on the Connellsville Division on January 6, 1905.

The following data are self-explanatory and show the actual results from the performance of this locomotive for the three and one-third year period ending May 5, 1908:

	Freight Service		
	Road	Helper	Total
Engine crew or constructive mileage (on basis of 6 miles per hour)	1,798	139,104	140,902
Locomotive or actual mileage	1,798	76,601	78,399
Time available for Transportation Department use	1,027 days, or 84.5%.		
Time unavailable for Transportation Department use	189 days, or 15.5%.		
Water used per pound of coal consumed	6.23 pounds.		

COST IN CENTS PER MILE RUN.

For	On Basis of	
	Const'ctive Mileage	Actual Mileage
Engine crew hire	10 16	18.27
Fuel	9.30	16.71
Repairs	4.96	8.92
Wiping, hostlering and dispatching	.89	1.60
Lubricating oil, grease and waste	.51	.91
Water	.45	.82
Sand, illuminating oils and other supplies	.29	.51
Total cost	26.56	47.74

The actual mileage includes only the road miles made by the locomotive and does not provide for the time that it was crewed and waiting for trains, working around terminals and switching, a considerable proportion of which occurs in helper freight service and for which an allowance is made in the constructive mileage.

The following essential features, which were somewhat radical as compared with the ordinary American railroad practice at the time this locomotive was designed, have given entirely satisfactory results: Articulated frame; elimination of truck wheels; Mellin system of duplex compounding and simpling; flexible joints to the receiver and exhaust pipes; Walschaert motion gear; combination hand and power reversing gear; high pressure piston and low pressure double-ported slide valves; high and low pressure steam balanced piston packing rings; method of securing high pressure cylinders to boiler; single disk balanced main throttle valve and 235 pounds working steam pressure.

No difficulty has been experienced with the tracking and riding qualities going forward or backward, around maximum curvature or on straight track, either when pushing, pulling or breaking trains or running light. The performance has demonstrated that neither leading nor trailing truck wheels are neces-

sary, which overcomes the objection to the added dead weight, increased number of revolving, swiveling and other parts and greater number of wheels and bearings for wear and lubrication. There is also the objection to truck wheels due to the increased resistance levers and friction when entering and leaving curves as produced through the supporting centers having to be carried farther forward from the swiveling point than would be necessary where truck wheels are not used and which latter arrangement provides a more flexible balancing and curving locomotive. The driver-wheel end play and flange wear has been more favorable than, and on slippery rail there is not the same relative loss of power as with the consolidation type locomotives, for the reason that in the former there are two seperate sets of connected driver-wheels and engines which can act automatically independent of each other in regulating the tractive effort, whereas with the latter all driver-wheels must act in unison.

With oil lubrication to the driver axle bearings, to the present date but one journal has required turning due to heating.

The combination of surge plates in the boiler with the use of the single disk main throttle valve has eliminated priming and provided dry steam at the high-pressure steam chests, and no trouble has been experienced with condensation in the low-pressure cylinders.

The Mallet locomotive has been operated by regular and pooled crews consisting of one engineer and one fireman and the latter have not been taxed to their physical capacity.

Injectors of 4,500 and 5,000 gallons per hour capacity are used on the left and right sides of the locomotive, respectively, either of which will supply the boiler when developing the maximum horse-power.

No defects have developed in the boiler sheets or in the method of attaching the high-pressure cylinders to the boiler. The fire-box is in excellent condition and with the exception of a few fire cracks extending from some of the rivet holes at the seams and at the furnace-door holes, but which have given no indication of leakage, is as good as when applied. The number of solid staybolts removed for partial and entire fractures and all other causes is 158, and the 2¼-inch diameter and 21-foot length flues have been reset but twice, not including the third resetting, which will be made this month.

The fire-box, staybolt and flue performance of this locomotive operating with 235 pounds indicated steam pressure has been more favorable than for consolidation simple type locomotives working under the same fuel, water and service conditions with 205 pounds indicated steam pressure.

The flexible joints at each end of the receiver pipe which conveys the high-pressure cylinders exhaust steam to the low-pressure cylinder valve chambers have received no attention with respect to either renewals, repairs or adjustment and there has been no leakage, probably due to the fact that the long lever arm results in but slight movement of the joints.

The Walschaert valve gear, which is the oldest now in use on any locomotive in this country, has more than demonstrated its superiority in every respect over the Stephenson and similar forms of motion gear for modern locomotive construction.

Taken as a whole, the design of the locomotive can be considered as satisfactory, and the only changes found necessary or made in the original construction have been to strengthen a weak cross equalizer and the driver springs; to change the flexible connections between the oil delivery pipes and the low-pressure cylinder steam chests and to rearrange the rocking and drop grates and operating gear.

While the locomotive receives fire cleaning, fuel, sand, water, washing out and minor running repairs at Rockwood, Pa., from which point it is dispatched for helper freight service, the heavier running and the classified repair work must be done at the divisional enginehouse at Connellsville, Pa., to which station it is diverted at periodic intervals.

As compared with consolidation simple type locomotives the fuel consumption per ton mile is considerably less on the level, somewhat less on the combined level and mountainous and slightly less on the mountanous lines.

This locomotive is doing the work of two standard consolidation simple locomotives and the results from its service has more than met the expectation of the builders and owners and has established the practicability and the advisability for the use of this class of power for the purpose as intended.

Erie Railroad Performance.—The Erie Railroad put into service during September, 1907, three Mallet articulated duplex compound steam types of helper freight locomotives, the high and low pressure sets of engines each consisting of four pairs of connected driver-wheels.

These three locomotives retired nine heavy decapod and consolidation locomotives with tractive powers ranging from 35,560 to 40,000 pounds. The cumulative performance of the three locomotives for the six-month period ending March 31, 1908, is shown in the following:

Total actual locomotive mileage	31,763
Total tractive power mileage	3,011,132,400
Average cost for maintenance per locomotive mile	12.86 cents
Average cost for maintenance per 10,000 tractive power miles	1.36 cents

The service of these locomotives to the present date has been satisfactory, but inasmuch as they have not yet been in use for a sufficient length of time to require classified repairs, the ultimate cost for maintenance can only be estimated.

A series of road tests were recently made to determine: First: The coal and water consumption. Second: The draw-bar push. Third: The steam distribution and back pressure in the high and low pressure cylinders, dryness of steam and horse-power.

[A full account of these tests will be found on page 212 of the June, 1908, issue of this Journal.—Ed.]

Great Northern Railway Line Performance.—The Great Northern Railway now has in service 22 of the larger or helper freight type of Mallet locomotives on the mountainous grades on its Cascade Division and 45 of the smaller or road freight type on the districts where the maximum grade varies from 0.6 per cent. to 1 per cent. To the present date the cost per actual road mile run for five of the helper freight locomotives, which were put into service during November, 1906, has averaged as follows:

Engine crew hire, wiping, hostlering and dispatching	27.06 cents
Fuel	55.22 "
Repairs	9.83 "
Lubricating oil, grease and waste	1.76 "
Sand, illuminating oil and other supplies	.39 "
Total	94.26 cents

The relatively high cost for fuel is due to the use of a semi-bituminous coal which will evaporate not to exceed 3½ pounds of water per pound of coal.

The cost per actual road mile run for 25 of the road freight locomotives that were put into a 201-mile continuous trip service in November, 1906, where the locomotives are pooled and crews changed midway of the district, averaged as follows to the end of the fiscal year, June 30, 1907:

Cost of repairs per mile	6.72 cents
Coal consumed per 100-ton miles excluding weight of locomotives	19.18 pounds

The use of the Mallet locomotives has enabled the following increase in the through freight train gross tonnage, not including the weight of the motive power:

Cascade Mountain Division: Increase from 1,050 to 1,450 tons.

Leavenworth, Wash., to Spokane, Wash.: Increase from 1,100 to 1,450 tons.

Whitefish, Mont., to Havre, Mont.: Increase from 1,300 to 1,700 tons.

Williston, N. D., to Minot, N. D.: Increase from 1,600 to 2,200 tons.

The above represents an increase of approximately 35 per cent. in the freight train gross tonnage and has eliminated congestion in yards which was previously occasioned by the use of consolidation locomotives.

With the present arrangement there is but one place on the entire system between Seattle, Wash., and St. Paul, Minn., where it is necessary to reduce through freight train tonnage—that is, a train leaving Seattle, Wash., with 1,450 tons arrives at Williston, N. D., a distance of 1,180 miles, with 2,500 tons and is then reduced to 2,200 tons, which the smaller Mallet road locomotives handle successfully without helper on a .72 per cent. grade.

From tests recently made on the district between Havre, Mont., and Cut Bank, Mont., it was found that the coal consumption averaged 14.3 pounds per 100-ton miles as compared with 28 pounds as consumed by the consolidation type locomotives, or a saving representing approximately 49 per cent. On the district between Minot, N. D., and Williston, N. D., the results of a sixty-trip test shows 11.04 pounds of coal consumed per 100-ton miles west-bound, and 9.27 pounds of coal consumed per 100-ton miles east-bound. The performance of the consolidation locomotives over the same district for the fiscal year ending June 30, 1907, averaged 19.25 pounds of coal per 100-ton miles, showing a saving of approximately 47 per cent. in fuel consumption.

On the district between Clancy, Mont., and Moodville, Mont., the annual performance of consolidation locomotives averaged 33.1 pounds of coal per 100-ton miles. From a series of tests made with the Mallet locomotives during March of this year, with an increase of 33⅓ per cent. in the train tonnage, the coal consumption was somewhat less than 25 pounds per 100-ton miles.

The conclusions with respect to the operation and maintenance of the Mallet road and helper freight locomotives as put into service on the Great Northern Railway Line is as follows:

Operation.—Very little trouble has been experienced in the handling of the heavier trains on the mountainous districts and less difficulty has been experienced on account of break-in-two's as compared with the simple consolidation type locomotives, which is accounted for by the automatic independent action of the two sets of connected driver-wheels and engines. It has also been demonstrated that the firing of these locomotives with the quality of fuel available is within the capacity of one fireman, although the use of some type of locomotive stoker is being considered on account of the heat from the furnace door opening.

From the performance to the present date it is thought that a considerably lower ratio of adhesion is permissible with the Mallet type locomotives as compared with other classes.

Design.—The question of flange wear was carefully considered due to the fact that the locomotives would be required to operate in both directions without turning. It was decided to provide leading and trailing wheels in combination with radial trucks and the results have been very satisfactory.

Maintenance.—The cost for repairs per mile run will necessarily average higher than for the simple consolidation locomotives, but on the basis of 100-ton miles it is materially reduced.

While no trouble has been experienced in keeping the flexible low-pressure steam and exhaust pipe joints tight they have required considerable attention and consideration is now being given to the use of a metallic packing.

On the first locomotives built the high-pressure cylinder saddles were secured to the boiler shell by means of studs, which caused considerable trouble due to their working loose and leaking. This difficulty has been overcome by the use of cast-steel cylinder saddles, which are riveted to the boiler shell.

During the winter months some trouble was experienced through having to keep the cylinder cocks open to relieve the condensation due to the low pressure steam coming in contact with the low pressure cylinder large wall area. It is the opinion that the use of some form of reheater or superheater would overcome this difficulty and bring about a considerable improvement in the efficiency.

On account of the trouble experienced in supplying sand to the rail ahead of the first driver wheels to the low-pressure or articulated engine, it was found necessary to locate an independent sand-box between the cylinders of the low-pressure engine, and which has overcome the difficulty due to the original sand-box location on top of the boiler.

The foregoing information is self-explanatory as to the results that have been obtained from the use of these locomotives, and justifies the general conclusions as set forth in this report.

Northern Pacific Railway Performance.—The Northern Pacific Railway now has in helper freight service 16 Mallet locomotives of similar type to those in use for the same class of service on the Great Northern Railway. Two of these locomotives are now in use on the Cascade Mountain Lines, and from which operation it is expected to secure some valuable comparative performance data. While some weak points have developed in the operation and maintenance, more especially in connection with the flues, the locomotives in general are rendering good service and haul an increase of about 300 tons in train up a 2.2 per cent. grade as compared with the other heaviest types of mountain-locomotives in similar service on that railroad.

Chicago, Burlington & Quincy Railroad Performance.—The Chicago, Burlington & Quincy Railroad has had one of the Great Northern Line helper freight Mallet locomotives in their service for some time past and has recently put into use two additional locomotives of this type. To the present date the committee has been unable to secure any detailed information of the performance of these locomotives except such as pertains to the one Great Northern Line type, which is included in the tabulation, photogravure, diagram and profile sheet and comparative performance data compilation (not reproduced).

American Railroad of Porto Rico Performance.—Three of the four Mallet locomotives in use on this railroad operate between Mayaguez and Lajas to transport the sugar-cane traffic.

Two locomotives, each in service about sixteen hours, handle a total of ninety loaded cars, each of 15-tons capacity, every working day, while the third locomotive is retained in reserve.

From Mayaguez to Filial Amor the Mallet locomotives are assisted by one consolidation type to hasten the formation of the loaded car trains and to distribute empty cars. From Filial Amor to Lajas the loaded and empty movement is handled by the Mallet locomotive.

The fourth Mallet locomotive is in service on another section. The performance is satisfactory.

Miscellaneous Railway Performance.—With respect to the three Mallet locomotives in service on the Central Railway of Brazil, and the two on the Guayaquil & Quito Railway of Ecuador, the committee regrets that up to the present time it has been unable to secure any detailed data pertaining to their performance or maintenance. What information has been secured indicates that they are giving satisfactory results and are suitable for the purpose for which they were constructed.

Size and Capacity of Safety Valves for Use on Locomotive Boilers.

Committee—F. M. Gilbert (chairman), G. W. Wildin, J. H. Manning.

No uniform practice seems to have prevailed in the past in proportioning safety valves to the work they are to perform. The locomotive builders follow specifications of the railroad companies, and it seems to have been the practice of the railroad companies to base their specifications on what has been done before on similar locomotives. The various railroad companies have fallen into the practice of specifying so many 2½, 3, 3½ or 4-inch valves, which, when reduced to exact language, does not mean anything definite. Obviously, two 3-in. valves having a sustained lift of ⅛-in. have a greater capacity for the discharge of steam than eight 3-in. valves having a sustained lift of 1-32 in. each. The committee does not wish to convey the idea that the two 3-in. valves having a sustained lift of ⅛ in. are better for the boiler than eight 3-in. valves having each a sustained lift of 1-32 in. It simply wishes to point out the errors that may arise from the practice of specifying so many valves regardless of the sustained lift.

Perhaps the most important part of any investigation should be the determination of the proper amount of evaporation which the safety valves shall be called upon to relieve. We already have information as to the maximum evaporation of locomotives from the tests at St. Louis in 1904, but the committee feels that the safety valves would never be called upon to relieve this amount from the fact that the combustion in the firebox is stimulated by the exhaust, and that this exhaust is caused from the use of the steam in the cylinders, so that, at a time of greatest evaporation, the steam is being used approximately as fast as it is generated. Hence, it remains for the investigators to determine what shall be deemed the proper amount of relief in safety valves. Then, too, the lift of valves of various sizes at the different pressures must necessarily be determined, as also the effect of this lift on the life of the valve seats and the tendency the lift of the valves may have to raise the water in the boiler.

It is no less important that some data be collected on open and muffled valves, and in this connection, considering the tendency of the muffler to retard the flow of steam through the valve, it is of importance that we review the work of Mr. Brownlee on the flow of steam through an orifice, which is contained in a "Report on Safety Valves" in the transactions of the Institution of Engineers and Shipbuilders in Scotland, Vol. XVIII, 1874-75, page 13. In this report Mr. Brownlee has compiled some data on the rates of discharge under a constant internal pressure, into various external pressures, upon which D. K. Clark, in his work on the steam engine, bases the following statements: "The flow of steam of a greater pressure into a receiver of a less pressure increases as the difference of pressure is increased, until the external pressure becomes only 58 per cent. of the absolute pressure in the boiler. The flow of steam is neither increased nor diminished by the fall of the external pressure below 58 per cent., or about four-sevenths of the inside pressure, even to the extent of a perfect vacuum. In flowing through a nozzle of the best form, the steam expands to the external pressure, and to the volume due to this pressure, so long as it is not less than 58 per cent. of the internal pressure. For an external pressure of 58 per cent. and for lower percentages, the ratio of expansion is 1 to 1.624."

From the foregoing, one is led to believe that the muffler produces no appreciable retarding effect on the safety valve. The committee feels that this should be verified in present practice.

As stated, it is essential that the amount of evaporation that the safety valves should relieve be determined. This can best be determined by applying two safety valves of known diameters and lift, which, according to the empirical formula, are known to be a little small. A third valve, of a larger diameter and set to pop at a somewhat higher pressure than the smaller valves, should be applied as a means of protection. If at any time during the test the two small valves go into action and the boiler pressure rises above the popping point, it would be reasonable to assume that the valves were of insufficient capacity. Another trial with valves of a larger diameter would no doubt prove of sufficient capacity. By changes in this manner it would be possible to apply two valves of sufficient capacity, and the diameter, lift, and form of valve being known, it would be a simple matter to obtain the amount of evaporation that the valves were called upon to relieve on the particular type of locomotive in question. It is important in this connection that the observation of pressures be very accurate, and the committee would suggest that a pressure-recording gauge be attached to the boiler to serve as a check on the observer. Perhaps the most reliable method of determining the lift of the valves would be to attach a rod to the top of the valve stem. This rod could be connected to a lift-recording gauge and also to a lift-recording mechanism, operated by a small motor, which, while recording the lift on the card, would also record the time element. This mechanism would give an accurate check on the gauge observations. It is understood, of course, that the lift measurements be made in the shop.

During the past few months the committee has been collecting data from the various railroad companies in order to arrive at some definite conclusions regarding existing practices. A letter of inquiry was also addressed to the various valve manufacturers and to the locomotive builders. The replies from some twenty railroads show that the safety valves now in use are of sufficient capacity, and on these reports the committee has based the calculations that are to follow. The records from twelve important roads show that the lift of the valves varies from 1-32 inch to 1-10 inch.

Taking the mean effective area of opening in square inches

per 500 square feet of heating surface, based on existing average practice of twelve railroads, we have developed the following empirical formula:

$$A \text{ equals } \frac{0.10266 \times H.\ S.}{P}$$

Where A equals the effective area of opening of the valve in square inches, H. S. equals the heating surface of boiler in square feet, and P equals the absolute pressure, or gauge pressure plus 15 pounds. The formula is based on an evaporation of 5.28 pounds of water per square foot of heating surface per hour, and it is recommended for use in the application of safety valves until such time as it is shown to be in error or, upon future investigation, a better one shall have been devised.

The valves of nine prominent valve manufacturers show a lift ranging from .03 inch up to .15 inch; taking an average of these lifts (0.087 inch) and working out the values for typical modern switching, freight and passenger locomotives, the following tabulation is given illustrating the application of the empirical formula:

Type of Locomotive.	Service.	Heating Surface, Square Feet.	Gauge Pressure.	No. and Size of Valves.
Pacific	Passenger	3,500	200	3—3½ inch
Consolidation	Freight	3,200	200	3—3½ "
6-wheel switch	Yard	1,900	200	2—3½ "

In this tabulation it will be seen that the number and size of safety valves for the Pacific and consolidation type locomotives are the same. It is recommended that the railway companies adopt one standard size of safety valve for all their locomotives, and not have, say, two 3-inch and one 3½-inch valve on the same locomotive. The adoption by railroads of one size of safety valve for all locomotives will bring about a uniformity that is much to be desired. The valves shown in the tabulation are assumed to have forty-five degree seats.

MINORITY REPORT.

By James Milliken.

The writer has declined to sign the report of the committee appointed to collect data on the sizes and capacity of safety valves and to suggest methods for carrying out tests to determine the data in connection therewith, for the following reasons:

First: Because there is given a definite recommendation founded on an empirical formula, that appeals to us as not having been proven as dependable.

Second: Because a definite size of safety valves is recommended for given capacity boilers without regard to location, when the location of safety valves, to give desired results, is just as important as the size of the valves themselves.

Third: Because of the further recommendation to use but one size of valves, regardless of the number that may be required on very large boilers.

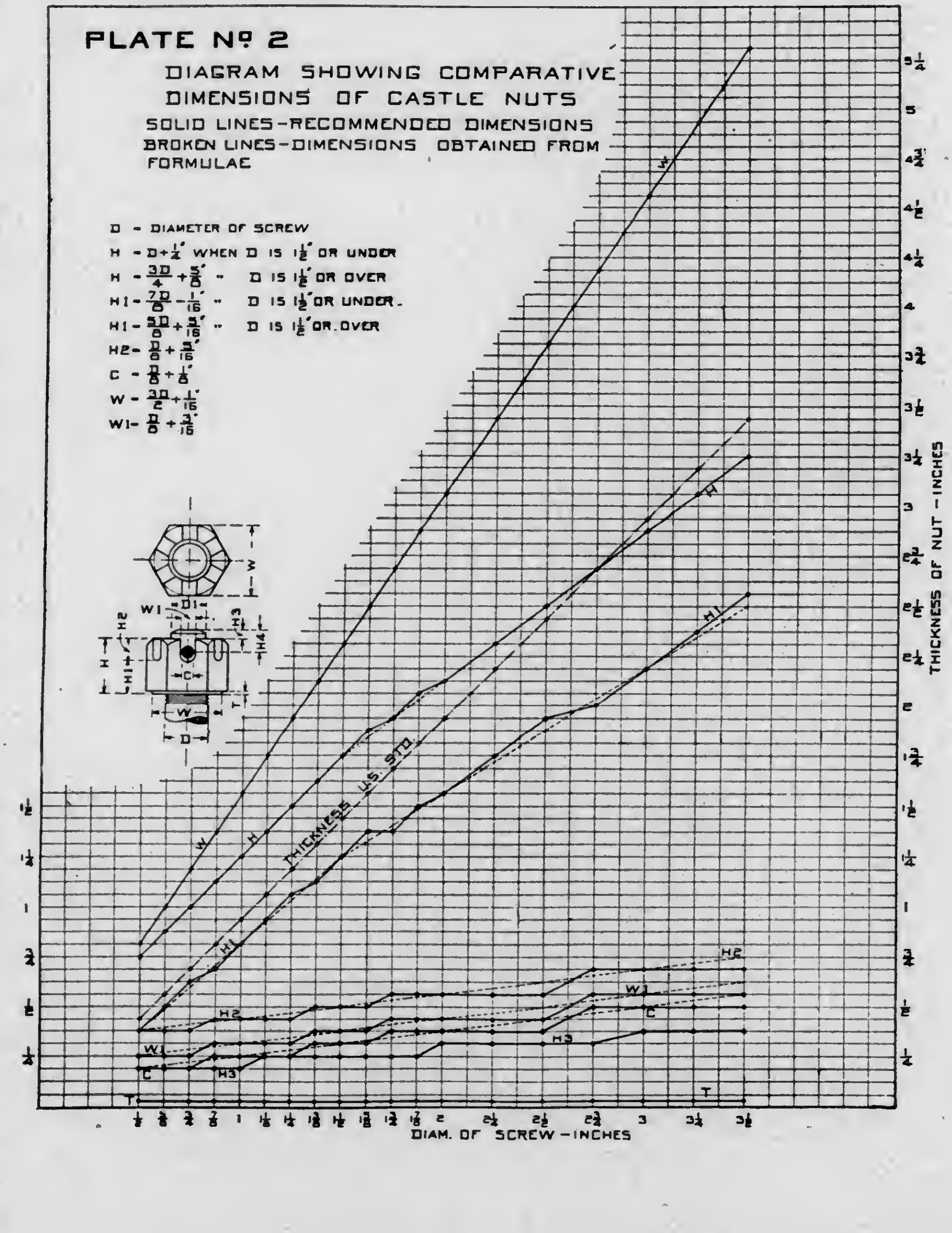
Fourth: Because, while a valve of a given diameter is suggested, no maximum lift, or free discharge, is recommended.

The committee has found this a large subject, and while a very important one, it is surprising what little valuable data is available; there are numbers of formulæ, generally quite old, and the majority evidently relate to stationary practice, and you will all coincide that there is a vast difference in the requirements for safety valves for stationary boilers and modern high pressure locomotive boilers. Stationary boilers usually have large steam spaces, where valves can be conveniently and properly located, and it is seldom that the entire volume of steam being generated is held in check suddenly. With the locomotive the boiler is urged to its utmost capacity; the throttle instantly closed; the draft, caused by the speed of the engine, only partially stopped and often induced by the use of the blower to prevent the emission of smoke; hence the greater necessity of the use of correct size and properly located safety valves. Quite a number of these formulæ are worked out on a grate area basis, which is eminently wrong, because the effectiveness of the grate area is dependent on the kind of fuel used, varying from anthracite to high grade, gas-bituminous, and even to other fuels, such as crude oils and petroleums. Other authorities use the heating surface of the boiler as a constant, and with this as a basis the evaporative efficiency of the boilers must be considered, and it is here that we feel we should be careful of our data.

The committee has used an evaporation of 5.28 pounds of water per square foot of heating surface, and recently constructed boilers, as brought out by the tests at St. Louis, have given over 12 pounds, or an increase of over 100 per cent.

I think that you will agree with me that the proper location of safety valves is just as important as their size; there are numerous examples of valves located on shells of boilers, attached to contracted steam spaces, or that have been located on pipe connections, that have resulted in entrained water and fluctuation of pressure in contracted steam spaces which has destroyed the valves and failed to relieve the boilers; while the same sized valves, when properly relocated, have worked satisfactorily.

In connection with the third reason, the writer objects to the use of more than two safety valves, when they can be had of sufficient capacity to relieve the boiler, believing the cost and care necessitated in maintaining them will more than offset the advantage of maintaining but one size. Each valve should be of sufficient capacity to generally relieve the boiler under ordinary working conditions; the second valve should be provided to take care of extraordinary or unusual conditions and should only come into play sufficiently often to insure its being kept in working condition. In other words, we should use two safety valves for the same reason that we use two injectors, one to supply the boiler ordinarily, the second as a relief in case of failure of the first or upon extraordinary momentary duty being placed on the boiler.



The writer feels, in view of the great importance of this subject and the small amount of absolutely accurate information that the committee has been able to gather this year, that the committee should be continued; that its scope should be increased to cover the subject of safety valves generally, muffled as well as open valves, and particularly to make recommendations, in addition to the capacity of the safety valves, for their location; that they be authorized to conduct tests to determine if any of the rules that are now in force are correct and if not to formulate such rules as will provide us all with good working basis. While the diameter by which safety valves are now usually ordered is quite important, a more important fact is the real area of outlet, and the size of this outlet will be governed not only by the foregone conclusions, but also by the pressure that the boilers carry.

Castle Nuts.

Committee—R. B. Kendig (chairman), J. F. DeVoy, H. P. Meredith, John Player, J. N. Mowery, G. S. Edmonds.

The committee strongly recommends the application of the castle nut to every important bolt on the locomotive and tender. Reports from various railroads which have made extensive use of the castle nut on locomotives indicate that a very appreciable reduction in the number of machinery failures is the immediate result obtained.

In deciding on dimensions for the castle nut it was thought advisable to consider two thicknesses for each size of nut. One series for general use and which could be applied in the transition period to bolts already having cotter pins for retaining the U. S. standard finished nuts, will be referred to hereafter in this report as the "castle nut." Another series, which in the larger sizes is considerably less in thickness than the U. S. standard nut, for use in service, such as on the valve motion parts, or other places where there is not sufficient clearance to apply a nut of full thickness, or where the strain on the bolt is in shear and in consequence there is no direct tension on the nut, will hereafter be referred to as the "thin castle nut."

In deciding on dimensions for castle nuts and thin castle nuts, the committee endeavored to follow, as far as practical, the proportions of the U. S. standard hexagon nut, with the following result:

The style of nut to be hexagon.

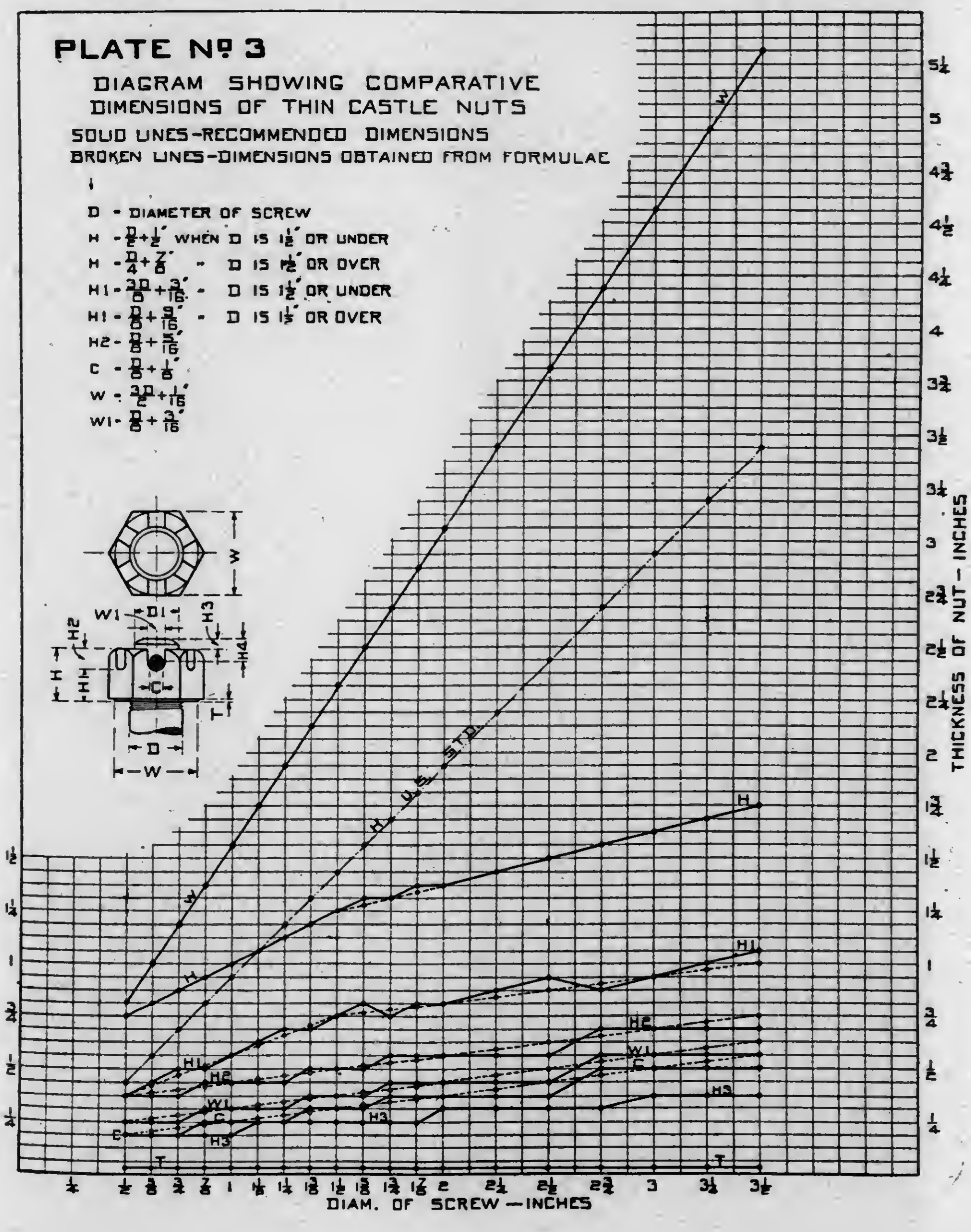
The width across flats, or short diameter of hexagon, to be same as the U. S. standard dimensions already adopted for the finished hexagon nut by this Association. No specific dimensions will be recommended for diameter across flats for rough nuts, other than that these should be practically the same as for finished nuts, simply allowing sufficient additional material to finish by grinding and buffing.

Threads to be U. S. standard thread and number of threads per inch to be the same as already adopted by the Association.

There are, however, a number of large-sized nuts used on the locomotive, which, on account of clearances, will not permit the use of the standard number of U. S. threads, and with the coarser threads there is a liability of their working loose. To take care of such cases Plate No. 4 shows the number of threads per inch to be used on this class of nuts, which will be known hereafter as the "special thin castle nut."

Number of castle slots, six; cut through center of flats. Sizes of castle nuts and thin castle nuts considered: from ½ inch to 2 inches advancing by eighths; from 2 inches to 3½ inches advancing by quarters.

In designing the castle nut, the first feature for consideration is the size of cotter pin or taper pin to be used. For this a formula has been devised: Diameter $= \frac{D}{8} + \frac{1}{8}$ inch (where "D" equals diameter of screw), using the nearest commercial size of cotter pin to the dimension found by the formula.



After deciding the diameter of cotter the castle slot is next considered, and for this a clearance of 1-32 inch between each side of the cotter pin and the wall of the castle slot was assumed. In arriving at the proper depth of slot, a depth 3-16 inch greater than the nominal diameter of cotter was assumed as sufficient for common practice. The proportions of castle slot thus selected make them susceptible to any method of manufacture.

Obviously the castle nut requires in the bolt or stud and within the castle slot, some form of cotter or pin to prevent the nut from turning on the screw, and means must be provided to insure the proper location of the pin hole with relation to the depth of castle slot. This feature will be covered by a minimum distance from end of bolt to top of castle nut and another dimension locating the pin hole with reference to end of bolt. Notice that the dimension of cotter pin and castle slot, also dimensions of bolt end and location of cotter pin hole in bolt will be the same for both the castle nut and the thin castle nut.

After deciding on the standard size of cotter pins to be used and then designing the castle slot to correspond, the next step in the design of the nut was to consider its thickness. In doing this the 1½-inch nut was taken as a starting or generating point. Then for the castle nut ¼ inch is added to the thickness of U. S. standard nut and for the thin castle nut ¼ inch was deducted. A minimum thickness of ¾ inch for ½-inch castle nut is required to give the proper castle slot proportions for the size of cotter selected. From this conclusion the committee was enabled to devise a straight line formula for the thickness of the castle nut and thin castle nut (Plate No. 1) which would give results corresponding with their conclusions as to the proper thickness for the ½-inch and the 1½-inch sizes. Intermediate thicknesses are obtained from the formula. Notice that thickness of the castle nut

increases by increments of 1/8 inch and the thin castle nut by increments of 1-16 inch for each 1/8-inch step in size of nut to and including the 1½-inch size. These formulæ if applied to the 3½-inch castle nut would give a thickness of 3¾ inches, and if applied to 3½-inch thin castle nut would give a thickness of 2¼ inches. These dimensions were considered as giving a nut entirely too heavy for practical use and were therefore reduced by ½ inch in thickness, thus making the 3½-inch castle nut 3¼ inches thick, and the thin castle nut 1¾ inches thick. A straight line formula was also devised covering the thickness selected for the 1½-inch and 3½-inch sizes. In these formulæ the thickness of castle nuts above the 1½-inch sizes increases by increments of 3-16 inch, advancing by quarters, and for thin castle nuts the increment of increase is 1-16 inch. These formulæ give, for the 1⅝-inch and 1⅞-inch sizes, a thickness in which a thirty-second dimension is necessary to express, and to avoid this feature the next higher 1-16-inch dimension is used instead of the dimension found by the formula.

The thickness of nuts obtained by these formulæ and the recommended dimensions are shown graphically in Plates 2 and 3. The thickness of U. S. standard nut is given for comparison. Notice that in all the formulæ the equations are given for convenience in terms of the diameter of screw.

PLATE No. 4

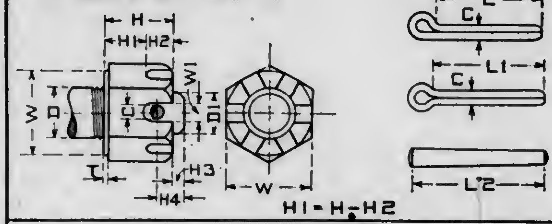


TABLE OF DIMENSIONS FOR CASTLE NUTS AND THIN CASTLE NUTS

DIMENSIONS GIVEN ARE IN INCHES

RECOMMENDED DIMENSIONS

NUT	D	DIAMETER OF SCREW	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2	2 1/4	2 1/2	2 3/4	3	3 1/4	3 1/2
NUT		No. OF THREADS PER INCH U. S. STD. CASTLE AND THIN CASTLE NUT	13	11	10	9	8	7	7	6	6	5 1/2	5	5	4 1/2	4 1/2	4	4	3 1/2	3 1/2	3 1/4
NUT		No. OF THREADS PER INCH FOR SPECIAL THIN CASTLE NUT	13	11	10	9	8	8	8	8	8	8	8	8	8	8	8	8	8	6	6
NUT	W	DIAMETER ACROSS FLATS OF FINISHED HEX. NUT	13/16	1	1 3/16	1 3/8	1 9/16	1 3/4	1 15/16	2 1/8	2 5/16	2 1/2	2 11/16	2 7/8	3 1/16	3 7/16	3 13/16	4 3/16	4 9/16	4 15/16	5 5/16
NUT	W	DIAMETER OF FACING COLLAR	13/16	1	1 3/16	1 3/8	1 9/16	1 3/4	1 15/16	2 1/8	2 5/16	2 1/2	2 11/16	2 7/8	3 1/16	3 7/16	3 13/16	4 3/16	4 9/16	4 15/16	5 5/16
NUT	T	THICKNESS OF FACING COLLAR	1/32	1/32	1/32	1/32	1/32	1/32	1/32	1/32	1/32	1/32	1/32	1/32	1/32	1/32	1/32	1/32	1/32	1/32	1/32
NUT	H	THICKNESS OF CASTLE NUT—ROUGH	13/16	15/16	1 1/16	1 3/16	1 5/16	1 7/16	1 9/16	1 11/16	1 13/16	1 15/16	2	2 1/8	2 3/16	2 3/8	2 9/16	2 3/4	2 15/16	3 1/8	3 5/16
NUT	H	THICKNESS OF CASTLE NUT—FINISHED	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	1 15/16	2 1/16	2 1/8	2 5/16	2 1/2	2 11/16	2 7/8	3 1/16	3 1/4
NUT	H	THICKNESS OF THIN CASTLE NUT—ROUGH	13/16	7/8	15/16	1	1 1/16	1 1/8	1 3/16	1 1/4	1 5/16	1 3/8	1 3/8	1 7/16	1 7/16	1 1/2	1 9/16	1 5/8	1 11/16	1 3/4	1 13/16
NUT	H	THICKNESS OF THIN CASTLE NUT—FINISHED	3/4	13/16	7/8	15/16	1	1 1/16	1 1/8	1 3/16	1 1/4	1 5/16	1 5/16	1 3/8	1 3/8	1 7/16	1 1/2	1 9/16	1 5/8	1 11/16	1 3/4
NUT		No. OF SLOTS IN CASTLE	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
NUT	W1	WIDTH OF SLOT IN CASTLE	1/4	1/4	1/4	5/16	5/16	5/16	5/16	3/8	3/8	3/8	7/16	7/16	7/16	7/16	7/16	9/16	9/16	9/16	9/16
NUT	H2	DEPTH OF SLOT IN CASTLE	3/8	3/8	3/8	7/16	7/16	7/16	7/16	1/2	1/2	1/2	9/16	9/16	9/16	9/16	9/16	11/16	11/16	11/16	11/16
BOLT	C	DIAMETER OF COTTER PIN HOLE IN BOLT	3/16	3/16	3/16	1/4	1/4	1/4	1/4	5/16	5/16	5/16	3/8	3/8	3/8	3/8	3/8	1/2	1/2	1/2	1/2
BOLT	H3	PROJECTION OF BOLT BEYOND TOP OF NUT	3/16	3/16	3/16	3/16	3/16	1/4	1/4	1/4	1/4	1/4	1/4	1/4	5/16	5/16	5/16	5/16	3/8	3/8	3/8
BOLT	D1	DIAMETER OF REDUCED END OF BOLT	3/6	7/16	9/16	11/16	13/16	7/8	1	1 1/8	1 1/4	1 5/16	1 7/16	1 9/16	1 11/16	1 7/8	2 1/8	2 5/16	2 9/16	2 3/4	3
BOLT	H2+H3	LENGTH OF REDUCED END OF BOLT	9/16	9/16	9/16	5/8	5/8	11/16	11/16	3/4	3/4	3/4	13/16	13/16	7/8	7/8	7/8	1	1 1/16	1 1/16	1 1/16
BOLT	H4	DISTANCE FROM CENTER OF COTTER PIN HOLE TO END OF BOLT	3/8	3/8	3/8	7/16	7/16	1/2	1/2	1/2	1/2	1/2	9/16	9/16	9/16	9/16	9/16	5/8	5/8	5/8	5/8
COTTER	C	NOMINAL DIAMETER OF COTTER PIN	3/16	3/16	3/16	1/4	1/4	1/4	1/4	5/16	5/16	5/16	3/8	3/8	3/8	3/8	3/8	1/2	1/2	1/2	1/2
COTTER	L	LENGTH OF PLAYER COTTER PIN	7/8	1	1 1/4	1 1/2	1 1/2	1 3/4	1 3/4	2	2	2	2 1/2	2 1/2	3	3	3 1/2	3 1/2	4	5	5
COTTER	L1	LENGTH OF COMMON COTTER PIN	1 1/4	1 1/2	1 1/2	2	2	2 1/4	2 1/4	2 3/4	2 3/4	3	3	3 1/2	3 1/2	4	4	5	5	6	6
TAPER PIN		SIZE OF TAPER PIN WHEN USED INSTEAD OF COTTER	°2	°2	°2	°4	°4	°4	°4	°5	°5	°5	°6	°6	°6	°6	°6	°8	°8	°8	°8
TAPER PIN	L2	LENGTH OF TAPER PIN	7/8	1	1 1/4	1 1/2	1 1/2	1 3/4	1 3/4	2	2	2	2 1/2	2 1/2	3	3	3 1/2	3 1/2	4	5	5

The committee wishes to submit for consideration of the Association a form of cotter designed by Mr. Player, of this committee, which overcomes some of the objectionable features of the common cotter when applied to the castle nut; one of the advantages being, that when put in place it cannot turn around at will, and in consequence the liability of its rattling loose is diminished. Another advantage is, that a saving in the length of cotter, as compared with the common cotter pin, is effected.

In the table of cotter pins (Plate No. 4) the sizes selected all appear in the manufacturers' standard list of spring cotters. While the practice is not general, some of the railroad companies are using a taper pin in place of cotter for retaining the nut, and for their convenience sizes of taper pins to be used in connection with the castle nut are given. The various sizes and lengths specified are contained in the manufacturers' list for taper pins.

In giving the dimensions for end of bolt it was thought desirable to show proportions of bolt with ends reduced below bottom of thread to present a plain surface for drilling the cotter pin hole. This is not necessary, however, as the same result can be obtained by filing a groove or flat to start the drill. On account of the necessary reduction of thread bearing and its consequent reduction in holding capacity of the nut, reduced bolt end should not be used with the thin castle nut, but instead the thread should be continued to the end of bolt. In preparing the end of bolt, so as to give protection to the thread, notice that the end is shown on the various plates preferably faced off flat for a distance equal to half the diameter of screw. The outer surface of end is chamfered for a distance equal to half the projection of bolt above nut.

Having explained the manner of arriving at the various dimensions of the castle nut and thin castle nut, the committee would make the following recommendations:

1. A series of castle nuts having U. S. standard thread with dimensions as shown.
2. A series of thin castle nuts having U. S. standard thread with dimensions as shown.
3. A series of special thin castle nuts having outward proportions the same as thin castle nuts, but having special number of U. S. threads, as shown.
4. Finished castle nuts to have diameter across the flats as shown. Rough nuts to be from 1-64 to 1-32 in. greater distance across the flats than the finished nuts, to provide for finishing by grinding and buffing.
5. Finished nuts to have facing washer on bottom with dimensions as shown. Rough nuts to have bottom corner slightly chamfered.
6. A series of standard cotter pins with dimensions as shown.
7. A series of Player cotter pins with dimensions as shown.
8. A series of taper pins with dimensions as shown.
9. Bolt ends projecting beyond the bolt with cotter-pin hole location as shown.

Fuel Economy.

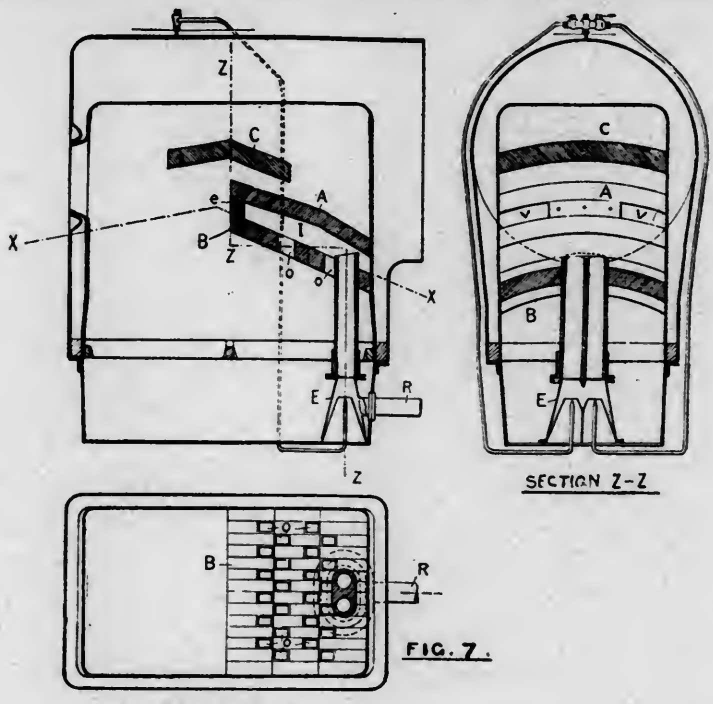
By W. C. Squire.

Among the first methods tried to prevent smoke was the continuous use of the blower in connection with a generous fire door opening. The firemen were also instructed to fire lightly and with good judgment. This was followed closely by the injected steam and air into the fire box, usually over the top of fire through thimbles perforating the water leg; then came the single scoop and double scoop methods. These devices and methods were also used in combination with plain fire arches of various kinds and makes.

At some critical period in the recent past, the operating officials realized that the coal pile was one of the largest individual items of expense, being approximately 50 per cent. of locomotive expense for maintenance, and from motives of economy, saw the necessity of reducing the cost of fuel per engine or train mile. Interests outside of the railroad, but with official encouragement, began the solving of the problem in the United States, while abroad the solution was in the hands of some of the advanced mechanical officials. Public opinion, government supervision and general agitation toward forest conservation, reduction of floods and other natural causes led to the serious consideration of the reduction of fire losses caused by the "locomotive sparks."

The way to prevent sparking is either to burn the cinders or not make them. This latter proposition is not entirely feasible in locomotive practice, as the heavy intermittent forced draft necessarily raises the smaller particles of coal from the grate, and these particles are carried with the gases into the flues and out of the stack.

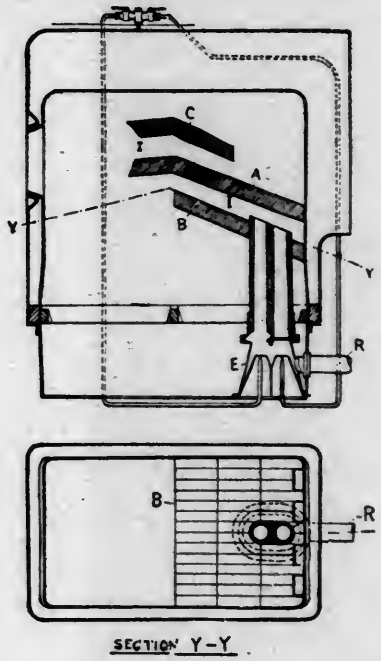
Tests made on the Purdue testing plant and later on the Pennsylvania R. R. plant at St. Louis in 1904, have shown that from 4 per cent. to 15 per cent. of all coal burned may be accounted for as cinders and sparks. Thirty-three per cent. of all the cinders and sparks made were retained in the front end, ranging as high as 60 per cent. Prof. Goss in "Locomotive Sparks," concludes that spark losses are greatest when the rate of combustion is the highest and the draft is highest, but this is also af-



SECTION Z-Z

FIG. 7.

SECTION X-X.



SECTION Y-Y

FIG. 8.

fected by the character of the exhaust. In connection with narrow fire boxes worked to maximum capacity the spark losses increase to 20 per cent. The character of coal has a great deal to do with the amount of sparks produced, a light and friable coal giving the greatest percentage of sparks.

The Pennsylvania Railroad tests show from 4 per cent. to 25 per cent. of coal fired accounted for as sparks and cinders. The American engines tested show the lowest ratios when compared with the foreign engines tested at St. Louis. The compound engine spark losses are away below those obtained from single expansion engines for total sparks thrown and caught.

Wm. Garstang's paper presented at the Western Railway Club on "Tests of Coal for Locomotive" gives results obtained from five kinds of coal; three tests are reported for each coal. The ratios of sparks to coal burned varies from 5 per cent. to 23 per cent., and strange to relate, there is shown but a small difference in the ratio obtained from speeds of 30 and 50 miles per hour. It can be taken as a general proposition that the greatest spark losses are obtained with the highest rate of evaporation per foot of heating surface per hour.

From the Purdue test and those at St. Louis it was found that cinders and sparks have from 75 per cent. to 90 per cent. the heat value of dry coal. Three and one-fourth per cent. to 4⅓ per cent. of the contents of sparks is volatile matter, and from 18½ per cent. to 32 per cent. is ash. These results are obtained with Brazil, Indiana, coal, and were determined from the tests made on the Purdue locomotive testing plant.

Prof. Goss' tests also show that the fuel value of a unit of sparks and cinders increases as the volume discharged increases, and that the size of the sparks ejected varies with the total amount produced. The greatest amount of sparks fall in an area lying between 35 and 150 feet from the center of the track, and the possibility of fires is greatest in these limits.

Schleyder Device.—About ten years ago Mr. Karl Schleyder, then in charge of motive power on the Austria-Hungary State Railway, urged by public clamor and more particularly by government regulations and rules, commenced a series of experiments with brick arches, looking toward smoke elimination, reduction of cinders ejected from the stack and also to secure as great a saving in fuel consumption as possible. From single arches he went to a series of arches, whose function was to force the oxygen, hydrocarbon gases, cinders, etc., into more intimate connection with each other to insure their mixture and consequent combustion before they reached the flues.

The investigations demonstrated the fact that if the gases could be diverted and forced through a series of flame ways with relatively narrow converging openings there was better combustion than if the flame ways were diverging. The heat in the arches, as would be expected, assists materially to heat the oxygen and other gases to the igniting point, besides intimately mixing them by the longer contact with the arch surfaces.

A noticeable feature in the designs tested is that the highest point in the top arch is usually coincident with the center line of boiler and that the top of fire door is also close to or coincident with the center line. With all the arches it was found that if a relatively large volume of air was admitted into the fire box through the fire door, combustion was improved. In some of the designs, the door was composed of a series of truncated cone of steel plate placed eccentrically so that the openings at the bottom were larger than at the top. This was supposed to allow more air to flow to the lower portion of fire box than to upper. The door, however, was run into the box somewhat beyond the door sheet and so became heated. The incoming air being divided into thin layers took up the heat in passing over the great area of sheet metal of which the door was made. That the air did become heated is proven by the long life of these doors, showing the air took up the heat and prevented burning of the plates. Another door was made of a large number of flues.

From these experiments the arches shown in Figs. 7 and 8 were evolved. Here arch B was placed below main arch A and run back to the flue sheet. To secure a better circulation of gases and to use all the arch surfaces, the arch B was perforated and a portion of the back aperture between B and A was closed as at *e*. Air was brought in from outside the fire box so as to be able to use the combustion chamber between arches A and B. To accelerate the flow of air into the fire box, steam blowers were placed at the lower end of the inlet pipes to supply air when engines were not using steam.

This evolution brought the next logical step. With a blower to force air into the fire box, the intake pipe could be continued to the front end and connected with a hopper to the smoke arch. Therefore, cinders finding their way to the front end would be directed to the hopper by the deflector plate, and the induced current in the pipe R, having a less pressure than that in the smoke box, the cinders and some of the front end gases would be returned to the fire box, thence into the hollow arch, and being mixed with air from the outside taken in at the lower portion of the intake pipe, a two-fold action was accomplished—smoke was eliminated by admission of air, and cinders were returned to the fire box to be consumed.

It has been claimed by some of the railroad officials using this device abroad that the return flue R carried all the black smoke and as well as all the cinders from the smoke box back into the fire box. As the area of the return flue R is about one-quarter that of the stack and one-twentieth that of the flues, the impossibility of the proposition is apparent. There is, however, no doubt about the cinders; the major portion are returned to the fire box. That some small cinders and ash are ejected with the front end gases there can be no question. It was early demontrated that the injected cinders striking the bottom of the arch had a sand blast effect on the brick, cutting through it in a very short time. Then the brick immediately above the tube was replaced by a cast steel or cast-iron baffle plate, arches B and C were discarded and arch A was made to suit the conditions of the fire box and fire-door openings.

Fig. 11 shows the complete device as used to-day on the Austrian State Railway. Fig. 12 shows the application to a modern 4-6-0 passenger engine in use on one of our important Eastern railroads. Fig. 13 shows, in a diagrammatic way, the whole device.

Mr. F. Elbel, general superintendent of railway construction, in an article in the *Railway Workmen*, of January 15, 1904, speaking of arches and their effect on the fire, says: "It is quite evident that the greater the resistance offered to the flame gases and cinders, and the longer the heat is retained in the fire box, the more advantageous will be the effects of combustion, con-

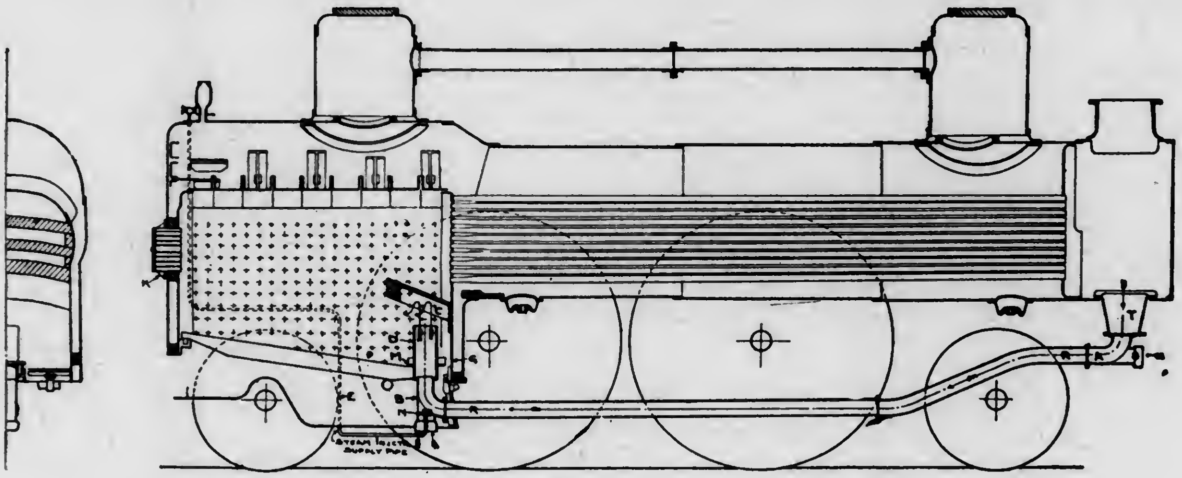


FIG. 11.

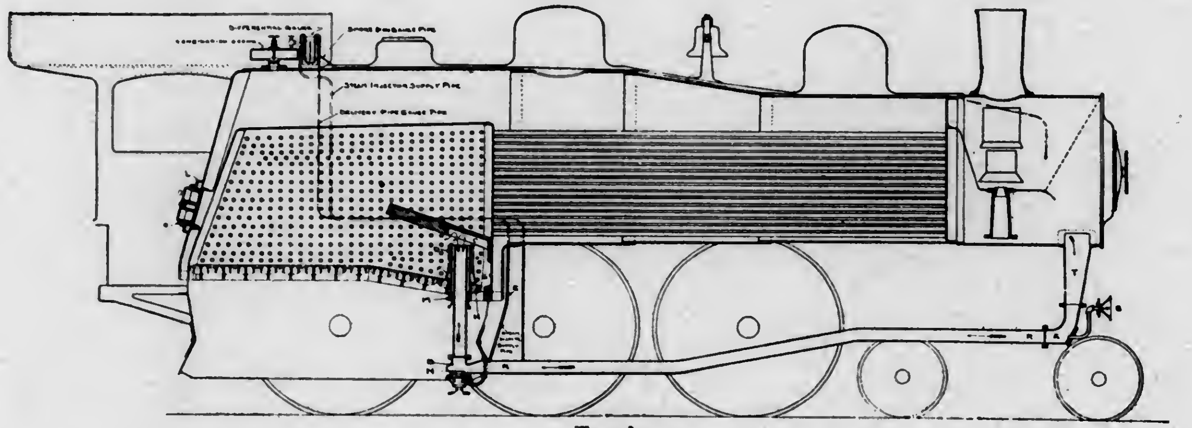


FIG. 12.

sequently, such devices must result in more complete combustion." In commenting on the Schleyder apparatus Mr. Elbel makes the remark: "I will state that the (baffles) fire arches are not an absolute necessity for the proper working of the apparatus. The cleaning of flues and smoke arch is entirely eliminated, being cleaned automatically. A distinct saving in fuel results, any kind of coal can be used, with no smoke or cinders, and engines steam freely.

From the results of a six months' test, there is shown a distinct fuel economy of 13½ per cent. and a difference between the cinder caught in smoke box for that period of 11.25 baskets for the equipped engine to 237.75 baskets for the non-equipped engine. It is evident from these figures that these engines do not have effective self-cleaning front ends.

Parsons Device.—There is also in use to-day a device, that is similar in many respects to the device just described, which was developed in New Jersey, but which does not use the brick arch, claiming it to be unnecessary. This device, known as the Parsons, uses two intake pipes, called heater boxes, placed in the back corners of the fire box and terminating in two flat nozzles with long narrow vents so constructed as to approximately converge the two incoming jets of air about one-third to one-fourth the length of fire box, and also to direct the air toward the lower or bottom rows of flues. The heater boxes are protected by rings of fire brick. The bottom of the heater boxes below the grate are connected with intake pipes terminating in funnels or air scoops arranged outside the wheels.

When standing at stations or running without steam, air can be forced into the fire box by means of steam blower pipes placed inside the heater boxes. As stated above the two devices are similar in general design in that air is taken into the fire box through tubes opening out into the atmosphere. The Parsons device uses the nozzles to direct and divert the air over the grates and coal, and depends upon the difference in pressure in the fire box and the outside air to force the air into the fire box when running. Standing or drifting, the blower acts the same as in the Schleyder device. The Parsons device does not return cinders from the front end or smoke box, nor does it use the arch.

Wade-Nicholson Hollow Fire Brick Arch.—The Wade-Nicholson hollow arch is the result of some years of development. The nature of the coal and the type and dimensions of the fire box are carefully considered. Air is admitted to the hollow cores in the arch through ferrules, preferably placed in the side sheets or through the throat sheets. The type of the orifices in the arches are shown in Figs. 18, 19, 20 and 21. Arches are either supported on water-tubes or studs.

In connection with the hollow main arch are the door arches shown in Fig. 18, air being admitted over the door through two 2-inch ferrules or air inlets; the main air arch has two air inlets of two ¼-inch ferrules. Two types of arches for long fire boxes are shown in Figs. 19 and 20, used in connection with the crown arches placed adjacent to the crown sheet and, being hollow, the air is admitted through the ferrule in the side sheets. In Fig. 19, the air for the main arch is taken through the throat sheets, and in Fig. 20 the arch is set back 18 inches from the flue sheet. This space is bricked in on top of the grate. This is a very shallow fire box; there is no room for the usual construction of arch. By this construction is formed the combustion chamber, which cuts off a portion of the grate area, resulting in combination with the crown arch, of a very efficient arch construction. Air is admitted to the arch from the ash pan in this particular design.

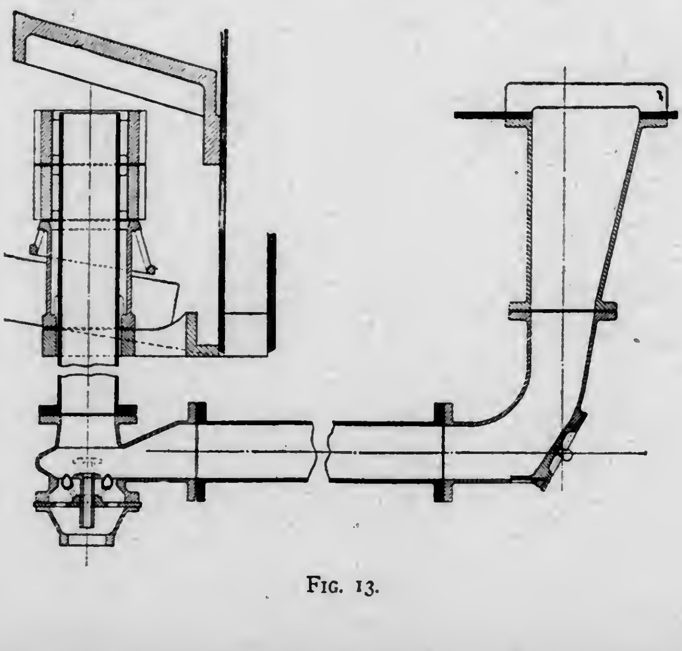


FIG. 13.

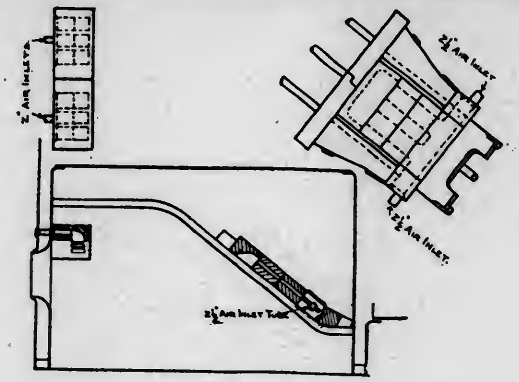


FIG. 18.

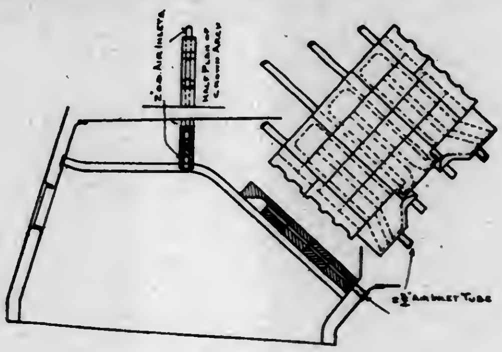


FIG. 19.

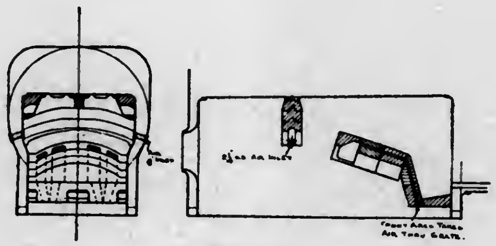


FIG. 20.

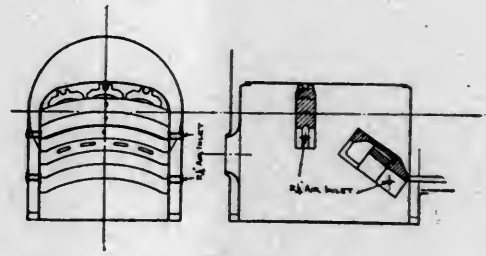


FIG. 21.

With the hollow arches just described, the amount of air admitted to the fire box is limited by the areas of the ferrules, but that which is admitted is heated to a reasonably high degree and improved combustion results, which results are known to be greatly in excess of those secured with plain arches. Tests made show an economy approaching 20 per cent. over similar or the same engines without the arches. Plain arches are conceded to give an economy approximating 10 per cent. over engines without arches. There are many points in favor of their use; there are strong arguments against their continuance.

With arches from 10 to 20 per cent. economy is possible, and where the cinders are also returned to the fire box, there is an opportunity for still further savings in fuel, and not the least of the benefits derived from any and all of these devices is that of the elimination of smoke.

Four-Cylinder Compound Locomotives in Service.

Committee—E. D. Nelson, chairman; John Howard, S. M. Vauclain, A. Lovell, J. F. Graham.

The committee found it impracticable at present to secure sufficient data obtained from the use of each individual design of balanced compound for comparison. Most designs have been in use but a limited time in this country, and it was, therefore, decided to confine the investigation to a comparison between balanced compounds as a general type, and single cylinder locomotives.

There are two natural divisions under which this subject can be discussed:

1. The comparative economy based on fuel consumed per unit of work done at the drawbar.
2. The comparative cost of maintenance.

Reliable data under these two headings, and compared on the same basis, should tell the ultimate economy.

There are, of course, claims made that a four-cylinder balanced compound is less destructive on track than a two-cylinder locomotive, but it is so difficult to measure this in cost that it will not be considered from that standpoint.

The comparative fuel used should be based on records from road service, but the committee has not been able to secure such data in sufficient quantity to draw conclusions.

The cost of maintenance involves many items, and the committee very carefully prepared a blank covering this phase of the subject, and the railroads having four-cylinder balanced compounds and simple cylinder locomotives were asked to prepare the information on a uniform basis. Apparently costs and records are kept in different ways, and the data is far from satisfactory.

Concerning, however, the matter as referred to in the first general division mentioned above, namely, the comparative cost of fuel for a unit of work at the draw bar, there are at hand valuable results of the tests on the Pennsylvania Railroad Testing Plant at the Louisiana Purchase Exposition in St. Louis, in 1904, of four-cylinder balanced compound locomotives.

Tests more recently made on the same plant at Altoona, with two-cylinder simple locomotives, fairly comparative in weight and general dimensions with those tested in St. Louis, are now for the first time available.

THE LOCOMOTIVES TESTED.

There were four balanced compounds tested at St. Louis. Of these, two were of the lighter class and one of them had a superheater. These two will be omitted from the comparisons.

The Atchison, Topeka & Santa Fe locomotive No. 535, and the New York Central & Hudson River R. R. locomotive No. 3000, however, were of about equal weight, and in this respect resemble the two simple cylinder locomotives recently tested on the Altoona Plant. The attached Table No. 1 shows the principal features. P. R. R. locomotive No. 5266 was tested, using coal

TABLE No. 1.

SHOWING GENERAL DIMENSIONS OF LOCOMOTIVES.

Locomotive Number.	535	3000	5266	3162
Railroad Company....	A. T. & S. F.	N.Y.C.&H.R.	P. R. R.	P. R. R
Simple or Compound .	Compound.	Compound.	Simple.	Simple.
Total weight in working order, lbs	201,500	200,000	184,167	184,933
Weight on drivers, working order, lbs..	99,200	110,000	110,001	121,867
Cylinders, diameter and stroke, inches.	15x25x26	15½x26x26	20½ x 26	20½ x 26
Diameter of driving wheels, inches	79	79	80	80
Firebox heating surface, square feet ...	220.3	202.83	156.86	162.61
Heating surface of tubes (water side), square feet........	3016.71	3255.27	2471.04	2483.91
Total heating surface (water side of tubes), square feet	3237.01	3458.1	2627.90	2646.52
Total heating surface (fire side of tubes), square feet	2902.05	3051.19	2319.26	2336.03
Grate area, square feet	48.36	49.90	55.5	55.0
Boiler pressure, lbs. per square inch	220	220	205	205
Valves, type........	Piston.	Piston.	Slide.	Piston.
Valves gear, type	Stephenson.	Stephenson.	Stephenson.	Walschaerts
Firebox, type........	Wagon Top, Wide.	Wagon Top, Wide.	Belpaire, Wide.	Pelpaire, Wide.
Number of tubes......	273	390	315	315
Outside diameter of tubes, inches	2¼	2	2	2
Length of tubes, inches	225.14	191.29	180	180

from the same mines as that furnished for the 535 and 3000 at St. Louis. Locomotive No. 3162 was tested with gas or high volatile coal.

It is now possible, therefore, for the first time, to make comparisons of two four-cylinder balanced compound and two two-cylinder simple locomotives, operated under testing plant conditions.

These four locomotives differed in minor particulars apart from their simple or compound cylinders, but, as already stated, they were of about the same weight and tractive force.

COMPARISON OF RESULTS.

From Fig. 2 it will be seen that the steam per indicated horse-power of the compound locomotives tested is more uniform throughout the range of horse-power than the simple engine. The greatest difference is at low horse-powers. This saving decreases as the horse-power increases, but if the boiler of the simple locomotive made it possible to continue the test to the maximum horse-power attainable with the compound, there might be more difference.

Inasmuch as the data of these tests for both compound and simple locomotives was taken at various percentages of cut-off at the different speeds, the statement above as to relative water rate and horse-power may be considered as obtaining under general running conditions.

From an inspection of Figs. 3 and 5, where the performance based on indicated and dynamometer horse-power is shown, as referred to coal, the saving of the compound throughout its range of action is indicated, and it is to be noticed that at the low indicated horse-powers (Fig. 3), the saving with the compound is greater than at horse-powers of about 800, and from Fig. 5 the least difference is shown at about 500 horse-power; horse-powers beyond these figures showing increased economy with the compound locomotive.

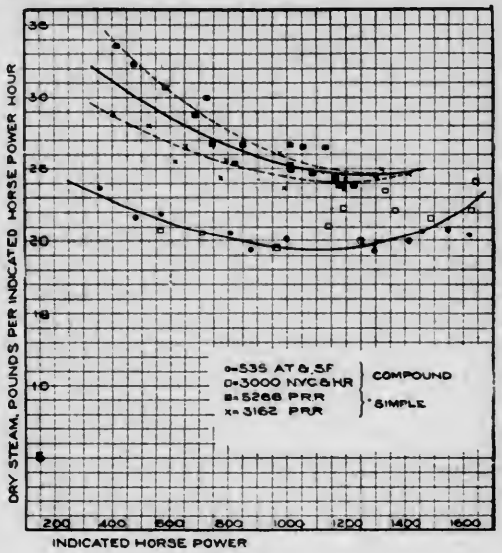


FIG. 2.

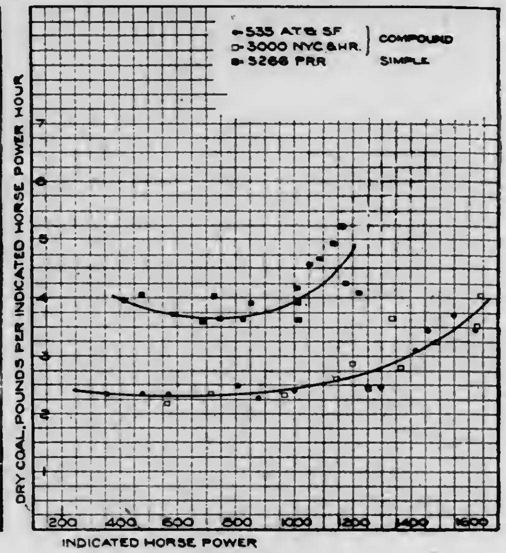


FIG. 3.

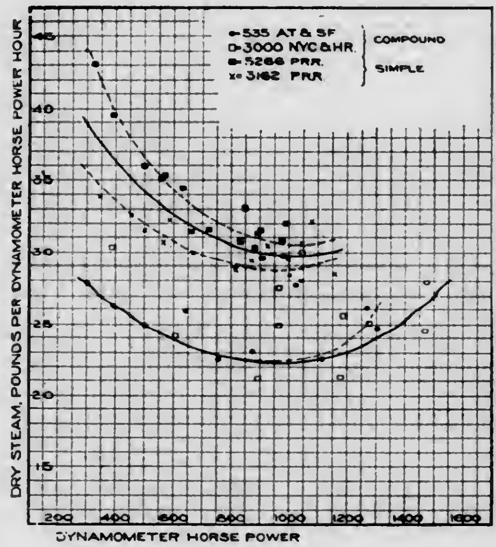


FIG. 4.

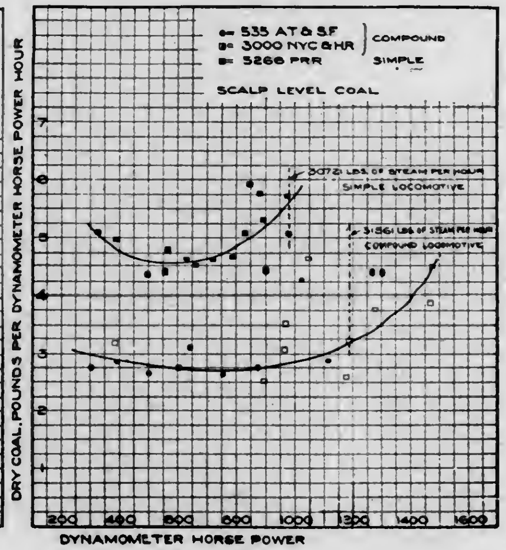


FIG. 5.

The advantage of compounding in adding to the capacity of the locomotive at speeds above those which may be called starting speeds, is clearly indicated. A boiler of the same heating surface on a locomotive equipped with compound cylinders, has a decided advantage over one equipped with simple cylinders, because the consumption of steam is less with the compound cylinders for a given horse-power developed.

It is, therefore, clear that a balanced compound locomotive, while more economical in steam and fuel than a simple locomotive, has also an increased advantage over the simple locomotive in capacity.

When developing 800 dynamometer horse-power, the compound uses about 2.70 pounds of fuel per horse-power hour at the drawbar, and the simple locomotive uses 4.85 pounds. Thus, the saving of the compound over the simple locomotive is shown to be about 44 per cent., based on fuel, this saving varying somewhat with greater and less horse-powers. These figures are based on testing plant conditions.

As indicating the increased capacity with compound cylinders, there is shown on Fig. 5 a vertical line where 30,721 pounds of water were being used by the simple locomotive while developing 975 dynamometer horse-power. When the compound locomotive was using approximately the same quantity of water, or 31,561 pounds per hour, 1,188 dynamometer horse-power was developed, an increase of over 11 per cent.

BALANCING.

In the Pennsylvania Railroad report of the St. Louis tests there are shown diagrams which illustrate the perfection of balance of the locomotives, both vertically and horizontally, and on Figs. 6 and 7 (not reproduced), similar results are shown for locomotive No. 5266.

It was made clear from the tests of the four-cylinder compounds, that great care is necessary in the design of the weight and location of the counterbalance in this type of locomotive, in order to realize all of the advantages that are possible from this type.

Since the St. Louis tests, however, the method of counterbalancing balanced compounds is much better understood, and it is doubtful if a simple locomotive can be as satisfactorily counterbalanced. From the tests recently made on the simple locomotive, it may be possible to much more effectually balance a simple locomotive than has generally been thought possible.

Locomotive No. 5266 was not observed to leave the rail at speeds as high as 320 revolutions per minute, or 76 miles per hour, and its critical speed, or the speed where severe fore and aft vibration began, was as high as 200 revolutions per minute, or 48 miles per hour.

The method used in balancing locomotive No. 5266 was to place in the driving wheels weights equivalent to all of the revolving and two-thirds of the reciprocating weights.

By actual weighing of the balance weights in the wheels, the right main wheel was found to have 17 pounds too much; the left main wheel 20 pounds too much; the right and left front wheels were found to have, each, 2.6 pounds too much, all these weights being at the crank pin radius.

SERVICE DATA.

In regard to the cost of maintenance and the cost of fuel, as actually developed in road trials, or in regular road service, the committee has been unable to secure sufficient data to present with any assurance of covering the ground in a satisfactory way.

CONCLUSIONS.

It has been shown in the foregoing that with the use of balanced compound locomotives, a very considerable saving in fuel and water, for the same work done, may be accomplished. It is equally clear from the discussion that the capacity of the locomotive with compound cylinders is increased.

The figures which have been given for fuel and water are, it is true, obtained on the locomotive testing plant where the conditions of running are uniform, and in road service the relative economy will undoubtedly be somewhat changed.

The testing plant does not give any figures on the cost of maintenance, and the committee, being unable to secure any data on this subject, is unable to give conclusions in regard to the ultimate economy.

The committee, however, is impressed, with the possible saving in regular service of balanced compound locomotives, and this would undoubtedly be realized with other types of compounds, but as the results in actual service are those which must finally be depended upon for ultimate economy, the committee would recommend to the members of the association a careful record of performance, in order to determine how far the economy in fuel and water can be realized, when all factors are considered.

The analysis already given and prepared for the purpose of determining the question of costs of maintenance, as well as the comparative cost of fuel, apparently covers the points involved sufficiently, but as already stated, the committee could not secure this data covering a sufficient number of compound and simple locomotives to draw definite conclusions.

Some action of the association, which will secure the coöperation of railroads in preparing information on this basis for the next convention, might produce valuable comparisons. It is necessary to have these records of performance covering the period from the time the locomotive was built and placed in service up to and including the most recent data concerning its performance.

This would involve probably considerable work in going over old records, but if some satisfactory conclusions could be reached in regard to this matter on the basis of ultimate economy, a decided step forward would be gained in railroad operation.

PERSONALS.

R. E. Fulmer has been appointed master mechanic of the Tremont & Gulf Ry., with office at Eros, La.

A. C. Miller has been appointed master mechanic of the Texas Midland Ry., with headquarters at Terrell, Tex.

R. B. Smith has been appointed foreman of motive power and equipment of the Cincinnati, Lebanon & Northern Ry., at Pendleton, Ohio, succeeding John Stutter, resigned.

F. C. Pickard has been appointed master mechanic of the Mississippi Central and of the Natchez & Eastern Rys., with office at Hattiesburg, Miss., succeeding W. J. Haynen.

The resignation of A. Bardsley as master mechanic of the Gulf and Ship Island R. R. at Gulfport, Miss., which was mentioned in the July issue, was caused by ill-health.

J. J. Waters has been appointed superintendent of machinery of the Mexican Central R. R., with headquarters at Aguascalientes, Aguas, Mex., succeeding Ben. Johnson, resigned.

H. F. Grewe has been appointed general foreman of the mechanical department of the Wabash Pittsburgh Terminal in charge of locomotive work, with headquarters at Rook, Pa.

G. H. Davis, master mechanic of the Clarendon & Pittsford R. R., has been appointed general foreman of the car department of the Wabash Pittsburgh Terminal, with headquarters at Rook, Pa.

J. H. Gimpel, master mechanic of the Vera Cruz & Pacific Ry. at Tierra Blanca, V. C., Mex., has been appointed master car builder, with office at Tierra Blanca. R. Fitzsimmons succeeds Mr. Gimpel.

W. T. Fitzgerald, master mechanic of the Wisconsin & Michigan Ry., has resigned to accept service elsewhere, and his duties are assumed by S. N. Harrison, superintendent, the office of master mechanic being abolished.

A. J. Isaacs, foreman of locomotive repairs of the Chicago & Alton R. R. at Kansas City, Mo., has been appointed master mechanic of the Chihuahua division of the Mexican Central Ry., with headquarters at Chihuahua, Chih., succeeding S. E. Kildoyle, resigned.

Charles E. Fuller, assistant superintendent of motive power of the Union Pacific R. R., has been appointed superintendent of motive power and machinery, with headquarters at Omaha, Neb., effective July 20. Mr. Fuller succeeds Mr. W. R. McKeen, Jr., resigned.

W. R. McKeen, Jr., superintendent of motive power and machinery of the Union Pacific Ry., has resigned and will devote his entire time to the McKeen Motor Car Co., which is being organized by E. H. Harriman, Mr. McKeen and others to build gasoline motor cars for railway uses.

George Hackney, superintendent of machinery of the Atchison, Topeka & Santa Fe Ry. from 1877 to 1891, died at Topeka, Kan., on June 19, aged 82 years. Mr. Hackney was one of the pioneer railroad men of the West. He was born in England and came to America in 1853 and was at one time shop foreman for the Menominee Locomotive Works at Milwaukee, Wis., and also shop foreman of the Chicago, Milwaukee & St. Paul Ry. He was later master mechanic on the Chicago & North-Western and the Chicago, Milwaukee & St. Paul Railways.

George H. Daniels, formerly and for sixteen years general passenger agent of the New York Central, died at Lake Placid, N. Y., on July 1. Mr. Daniels was born in 1842 at Hampshire, Kane County, Ill. In 1857 he worked as rodman on an engineer corps of the North Missouri, now part of the Wabash, but his railroad career practically began in 1872, when he was appointed general freight and passenger agent of the Chicago & Pacific, now part of the Chicago, Milwaukee and St. Paul Ry. In 1880 he was made general ticket agent of the Wabash, St. Louis & Pacific, now the Wabash R. R. Two years later he became commissioner of the Iowa Trunk Line Association and also commissioner of the Colorado Railroad Association. In 1884 he was also made commissioner of the Utah Traffic Association, and two years later became commissioner of the Central Passenger Committee. The next year he was appointed assistant commissioner of the Central Traffic Association and chairman of the Eastbound Passenger Committee. In 1887 he was elected vice-chairman of the Central Traffic Association and chairman of the Eastbound Passenger Committee. In 1889 he was appointed general passenger agent of the New York Central & Hudson River R. R., and as the creator of the very efficient advertising department of that company became known throughout the world. He was relieved of the heavy responsibilities of the passenger department in 1905, and resigned in May, 1907.

Errata.—In the tabular comparison of recent locomotives, page 230 of the June, 1908, issue, will be found two typographical errors as follows: Under the head of Pacific type locomotives, the ratio, "T. E. x diameter drivers ÷ total H. S." for the Erie locomotives should be 699 instead of 669, as shown. Also the ratio of "Total heating surface ÷ cyl. volume" for the Baldwin balanced compound of the A. T. & S. F. Ry., shown in the eleventh column, should be 310. instead of 3.10.

Forests Fast Disappearing.—The forests of this country, the product of centuries of growth, are fast disappearing. The best estimates reckon our standing merchantable timber at less than 2,000,000,000,000 feet. Our annual cut is about 40,000,000,000 feet. The lumber cut rose from 18,000,000,000 feet in 1880 to 34,000,000,000 feet in 1905; that is, it nearly doubled in 25 years. We are now using annually 500 feet board measure of timber per capita, as against an average of 60 feet for all Europe. The New England supply is gone. The Northwest furnishes small growths that would have been rejected by the lumberman thirty years ago. The South has reached its maximum production and begins to decline. On the Pacific coast only is there now any considerable body of merchantable standing timber. We are consuming yearly three or four times as much timber as forest growth restores. Our supply of some varieties will be practically exhausted in ten or twelve years; in the case of others, without reforesting, the present century will see the end. When will we take up in a practical and intelligent way the restoration of our forests?—*James J. Hill at the Governors' Conference.*

(Established 1832).

AMERICAN ENGINEER AND RAILROAD JOURNAL.

PUBLISHED MONTHLY

BY

R. M. VAN ARSDALE

140 NASSAU STREET, NEW YORK

J. S. BONSALL,
Business Manager.

R. V. WRIGHT,
E. A. AVERILL, } Editors.

AUGUST, 1908

Subscriptions.—*$2.00 a year for the United States and Canada; $2.50 a year to Foreign Countries embraced in the Universal Postal Union. Remit by Express Money Order, Draft or Post Office Order. Subscription for this paper will be received and copies kept for sale by the Post Office News Co., 217 Dearborn St., Chicago, Ill. Damrell & Upham, 283 Washington St., Boston, Mass. Philip Roeder, 307 North Fourth St., St. Louis, Mo. R. S. Davis & Co., 346 Fifth Ave., Pittsburg, Pa. Century News Co., 6 Third St., S. Minneapolis, Minn. W. Dawson & Sons, Ltd., Cannon St., Bream's Buildings, London, E. C., England.*

Advertisements.—*Nothing will be inserted in this journal for pay,* EXCEPT IN THE ADVERTISING PAGES. *The reading pages will contain only such matter as we consider of interest to our readers.*

Contributions.—*Articles relating to Motive Power Department problems, including the design, construction, maintenance and operation of rolling stock, also of shops and roundhouses and their equipment are desired. Also early notices of official changes, and additions of new equipment for the road or the shop, by purchase or construction.*

CONTENTS

It was unfortunate that it was not possible to give more time to the consideration of the report of the committee on passenger and sleeping car ventilation at the last Master Car Builders' convention. This report, which is largely reprinted elsewhere in this issue, is exceptionally valuable and is worthy of careful reading and study. It is certainly to be hoped that it may result in some practical improvement in this connection, particularly in regard to sleeping cars. To say that the occupant of the lower berth in a sleeping car, on the hot and sultry nights which have been so numerous during the past month, is uncomfortable, is putting it very mildly. This report points out a number of ways in which this discomfort during hot weather, as well as an almost equal condition during the cold nights of winter, can be relieved and the traveling public would, beyond doubt, greatly appreciate any efforts that may be made to discover the practicability of the schemes suggested.

The action of the American Railway Association at its April meeting, in adopting resolutions concerning the co-operation and harmonizing of the work of the various voluntary railway associations practically amounts to giving the findings and recommendations of such bodies a much greater value and importance than they have heretofore assumed. If the spirit of the resolution is fully carried out it will mean that any recommendations of any one of the 33 associations listed, which appears in print with the authority of that association, can be assumed to carry official sanction. This will act in raising the grade of many of these associations which have heretofore been chiefly educational or social in their character and will put them in a position of greater importance and usefulness, both to their own members and to the railroad companies. Incidentally it will also greatly reduce the opportunity of their causing any great damage by ill advised recommendations of some member or committee who may not be fully conversant with all phases of his subject.

As far as the Master Mechanics' and Master Car Builders' Associations are concerned, this action will have but little effect as they have both always worked in co-operation with the American Railway Association to a very large extent.

MOTOR CARS.

The self-contained motor car for railway use has been a very attractive subject of discussion and experiment for a good many years and taken together there has been quite a large number of these cars built in this country and even more on foreign railroads. These have, with comparatively few exceptions, proved to be failures for one reason or another. Most of them have been more or less successful from a mechanical standpoint, but have failed in various ways as an operating proposition.

In general, motor cars can be divided into three practical types, each of which has its own inherent advantages and disadvantages. These are the gasolene type, the gas-electric type and the steam type. They all, however, have one common disadvantage in the fact that the motive power and the car body are practically inseparable and it is impossible to care for the former in the same place and manner as other motive power on the road is cared for. It is also necessary to put the whole car out of commission whenever the motive power needs attention. Even at the best these cars are expensive and if the service is to be handled satisfactorily with them it will always be necessary to have an extra unit or so for use in cases of emergency, which will make the capital charge of the equipment for this service comparatively heavy.

It is difficult to understand what there is about the light traffic of a branch line that cannot be handled by a small, highly specialized locomotive, preferably of the 0-4-0 tank type, attached to a combination passenger and baggage coach, fully as well as by a self-contained and propelled motor car. Such an arrangement has many advantages both in respect to the original cost of the equipment and the maintenance charges. In this connection it is instructive to note that the Bavarian State Railways, which have for several years been operating steam motor cars and have over thirty in service, have decided to discontinue building this type of equipment and have designed a small, but very powerful, four-wheel tank locomotive which can be coupled to a light passenger car and perform the service with equal satisfaction. This arrangement simply amounts to separating the motive power from the passenger compartment of a steam motor car and permits the former being taken care of in the regular engine house. It also provides equally good service with a smaller capital expenditure and gives a greater flexibility to the train capacity.

MASTER CAR BUILDERS' ASSOCIATION.

ABSTRACT OF COMMITTEE REPORTS.—(CONTINUED FROM PAGE 271.)

Ventilating and Heating of Coaches and Sleeping Cars.

Committee—S. G. Thomson, chairman; B. P. Flory, T. H. Goodnow.

The work as assigned to the committee on the ventilating and heating of coaches and sleeping cars was: "To investigate methods for the regulation of the temperature and the supply of fresh air to passenger cars, with special attention to sleeping cars, and to recommend plans which provide for the regulation of the heat and the air supply by the occupant of each berth."

The principles involved in this subject are so broad, the variations of the conditions so great, and the state of the art so undeveloped, that the committee considered it best to limit its investigation and suggestions to general lines, and not to include any more detail than was necessary to illustrate some of the important principles, and to describe a few of the best methods in use.

Special effort was made to obtain information from the Pullman Company concerning its ventilating experience and plans for betterments, as well as to have one of its representatives present at a committee meeting; but the Pullman Company did not have anything to present. For this reason the conclusions and recommendations as given in this report, concerning the Pullman equipment, are not based on any definite information or data that have actually been obtained, but rather are formulated from the views of the various railroad officers as expressed in their communications and from the personal views of the committee.

The information which the committee was able to obtain failed to reveal any variety of thoroughly successful ventilating systems which have been extensively tried out, or new devices which are being developed; and the work as outlined seemed to resolve itself into a question of collecting information concerning the few older systems and devices that have been in use, and of developing arguments and ideas concerning new methods, such as any one might wish to propose.

About forty years or more ago, Professor W. Ripley Nichols, of the Massachusetts Institute of Technology, made some investigations of a system in use at that time known as the Winchell Ventilating System. This system was arranged so that air was admitted to the car at the end under the front hood, then allowed to distribute as it would through the car, and to pass out under the rear hood, without any attempt being made to warm it as it entered. Professor Nichols determined that 7,000 to 10,000 cubic feet of air per hour was furnished under favorable conditions. Later experiments with this system at Altoona indicated that 15,000 to 25,000 cubic feet of air per hour was furnished, depending on conditions. It was also found that the movement of air in the car was hardly perceptible when the car was standing still, there being even less air movement with the large openings than is found in many of our more tightly closed modern coaches.

The next type of ventilating system was that found in the early type passenger coaches, known as the Spear Stove System. It consisted of hoods or intakes at diagonal corners of the car, which intakes were connected with the coal stove. The movement of the car forced the air down around the stove and into a box running the length of the car along each side above the floor. From this boxing or duct the warmed air was admitted into the car through various openings in the side of the duct. It then ascended through the body of the car and passed out through the deck sash. This system was a great improvement over any that had thus far been tried, but it was still subject to the following defects: When the car was not moving, the current of warm air was reversed and passed from the car out through the intake. Another trouble was, that the proportion of exits and intakes was not such as to give a balance of pressure between the inside and the outside of the car, and the exits were so much in excess of the intakes that cold air in the winter time would be drawn in around the windows and through every crevice. The trailing deck sash gave rise to various cross-currents, since it was often found that air would enter the car through the deck sash instead of going out, as it should. These cross-currents, in the upper deck interfered with the proper burning of the lamps, and did not change the air to any extent as low down in the body of the car as the breathing line. The deck sash also admitted cold draughts, cinders and smoke overhead, to such an extent as to be very annoying. The construction of the deck sash had not been brought up to the higher state of development in which we find it in use to-day on some of the most improved equipment.

The Spear Stove System was modified later by removing the stoves and by substituting for them steam radiator pipes extending the length of the car in the air duct, and by adding ventilators on the upper deck of the car roof. This was an improvement, in that it eliminated the stove and gave an exit for air, other than the deck sash. With some slight modifications, such as the adding of extra radiators at the ends of the car, just inside the doors, this was the type of ventilating system that immediately preceded the modern indirect systems now in use.

The deck sash system, which is now very generally used, was evolved from various former arrangements of deck sash, and its construction has been improved so as to eliminate many of the objectionable features of the former arrangements. The use of wire netting outside of the sash has largely eliminated dirt and cinder entering. This deck sash method of ventilation necessarily separates the heating and ventilating systems, and does not warm the air before it comes into the car. No special air intakes are provided, except the deck sash, and the change of air in the car is limited to the amount that will pass in and out through these openings. When the deck sash is thrown open in the winter time, it very quickly relieves an overheated car, as some of the cold entering air drops into the body of the car to take the place of the heated and vitiated air. This momentary dropping of cold air is effective in relieving a stuffy and overheated car, but continuous draughts created in this way are very objectionable to passengers in cold weather. In the summer time, this dropping of the cool currents is not so pronounced, and the movement of air is not sufficient for good ventilation. This system has been used in the Pullman cars for a long time, but it is now being modified by the application of a late type of the Garland ventilator to the deck sash. This ventilator has eliminated the objectionable down-draughts by creating a strong exhaust, and thus directing all the currents upward and outward through the roof.

The present standard ventilating arrangement of the Pennsylvania R. R. was started in its development more than ten years ago, and is the result of a number of years of study and experimental work. A large number of tests were made, resulting in modifications and changes, each change being followed by runs on the road, and by analyses of air taken from the cars under various conditions. The arrangement, as thus developed, has been gradually applied to cars, until it is now in service on more than one thousand coaches. The system admits the air through hoods located on diagonal corners of the car. The air passes down a vertical boxing to a horizontal duct under the floor, which duct runs the length of the car between the side and the adjacent intermediate sills. Then the air ascends through slots in the floor to a longitudinal boxing or duct containing steam pipes, extending along the sides of the car, above the floor and immediately over the air duct, thence through galvanized iron tubular pipes under each seat to the aisle, where it ascends and passes out through globe ventilators located over the lamps along the center line of the upper deck.

The system is designed to furnish one thousand cubic feet of fresh air per hour per person, while working normally on a moving train. This figure was based on there being 60 passengers to the car, which would require 60,000 cubic feet of air per car per hour, a complete change of air in the car fifteen times per hour, or once every four minutes. That this amount of air is furnished by the ventilating arrangement, has been proven by numerous tests which were made during its development. Samples of air were taken under various conditions from cars filled with workmen, while the train was running at speed with all the ventilators open; also, while the train was running with all the ventilators closed, as well as while it was standing still with all the ventilators open. The analyses were made by a test for carbonic acid in the air, and the calculations were made by determining the amount of fresh air that it would take to dilute the estimated amount of carbonic acid exhaled by the number of men in the car, so that the air in the car would equal in carbonic acid the amount that was actually found to exist in the samples taken. A representative test made in the winter time under normal conditions, showed by this method of calculation that 62,400 cubic feet of air per car per hour was furnished, while the train was running about 30 miles per hour with all the ventilators open; 27,000 to 37,000 cubic feet of air was furnished while running with all the ventilators closed, and about 23,000 cubic feet while the train was standing with the ventilators open.

The operation of the system is not entirely dependent on the movement of the car; since, when the car is standing still, the normal circulation of air is maintained by the rising heated cur-

rents, when there is heat or light in the car. This natural rising of the warm currents will furnish, under favorable conditions, about one-third of the change of air necessary for a crowded car. When a car is standing at a terminal and there is neither heat nor light in it, which is usually in the summer time, the proper ventilation is not furnished through the ventilating system, but is obtained by keeping the windows and doors open as much as possible.

As a whole, the system is efficient in almost every way when the train is running, but when the train is standing still, the system itself does not provide for any better ventilation than is afforded by the ordinary deck sash arrangement. This can clearly be seen in a smoking car: first, by observing the accumulation of smoke and the stillness of the air when the car is standing at the station awaiting departure with the doors open, and then, after the train starts and the doors are closed, by watching the gradual disappearance of the heavily laden air until the train has attained its speed; at which time the air in the car has become fresh and the car is almost cleared of smoke.

The conditions that prevail while a train is standing still are so quickly relieved after it gets into motion that the insufficient amount of ventilation supplied in the former case is comparatively of minor importance. This means that, in any system of day coach ventilation, we have first to consider the condition in which the passengers are kept enclosed for hours at a time during a long trip, and then, after this is made satisfactory, to take care of the local terminal conditions in whatever way seems advisable and in accordance with the necessity. This terminal condition is of more vital concern in the case of sleeping cars which may be in such service as require them to stand in a station during the night for a number of hours before the departure or after the arrival of a train. The only way to solve this difficulty will be to install a forced-draught system on a few cars that could be assigned exclusively to such service as was thought to warrant the extra expense. This would involve the installation of fans, ducts and registers, arranged according to the type of car.

The Pullman ventilating system will be recognized as the direct opposite to the Pennsylvania arrangement, in that the heating and the ventilating systems are separate, and the air is not heated before it enters the car. This deck sash arrangement is used almost universally all over the country, in day coaches as well as in the sleeping cars. Many roads are using the earlier type of drop and trailing deck sash, while others have improved their conditions somewhat by introducing special ventilators, either in place of or in connection with the deck sash, or on top of the upper deck. There has been a tendency during the last few years to use various types of ventilators in the upper deck which induce strong exhaust currents from the car, without providing any intake. This has considerably changed the ventilating conditions in cars equipped with the deck sash system. The former theory was to allow fresh air to enter from above and to drop to the breathing line, while the latter theory is to create a sufficiently strong exhaust from the upper deck to keep the currents always moving upward, and to draw out the vitiated air in sufficient quantities to keep the car well ventilated, allowing the supply to come from wherever it will.

The strong exhaust principle has not been in use a sufficient length of time on coaches and Pullman cars to allow any definite conclusions to be reached in this report concerning its general application to existing equipment; but several ideas occur in this connection which may be worthy of mention. The fact that no special intakes are provided to supply the large amount of air that should be furnished for good ventilation makes it necessary that this quantity of air must be drawn either from the ends of the cars, or in through the cracks around the windows, or down the lamp jacks, if such happen to be open into the body of the car. This condition would be most objectionable in a day coach, as the admission of air through the lamp jacks would interfere with the proper burning of the lights, and it would not change the air to any extent in the lower part of the car near the floor. On the other hand, an admission of any such quantity of air as 60,000 cubic feet per hour through the cracks around the windows and doors, would, if it could be accomplished, create intolerable draughts, and would make the occupation of the seat next to the window very undesirable in cold weather. These strong exhaust ventilators applied to a day coach with its single windows will always set up excessive draughts, even if very much less air is being drawn through the car than is required for good ventilation, and the result necessarily will be a condition of insufficient ventilation, and an excessively draughty car. The question of providing inlets to relieve the window draughts without changing to the indirect system of heating is a difficult matter, for the reason that any admission of untempered air at or near the floor would be just as objectionable as the window draughts, if not more so, since a cold floor is most certainly to be avoided. The strong exhaust principle should not be used as the only means of ventilation in building new coaches or Pullman cars, and should not be carried too far in applying it to existing equipment, without also providing an adequate intake of fresh, warmed air. If the heating system is not modified in the application of the exhaust ventilator to the present equipment, the strong, cold draughts are apt to be more of an objection than the additional amount of air movement is to be an advantage.

The exhaust ventilator with a strong draught, when applied to the Pullman car, has to meet a different condition and has a different effect than when applied to the day coach; since the Pullman cars are more tightly constructed than the coach, and they do not need as much air for good ventilation, on account of the correspondingly smaller number of passengers that can occupy them. The window draughts are reduced to a minimum by the double sash, and the ends of the cars are tightly enclosed. A strong exhaust ventilator arranged to draw from such an enclosed space seems to be a great opposition of forces. Under such conditions, the amount of change of air and the capacity of the ventilators necessarily depends on the amount of air that can be drawn from the ends of the car and through the openings at the windows. Such a partial vacuum created in the car body will doubtless cause a movement of air from the point of least resistance and thus cause an excessive draught at an open window screen or ventilator or vestibule door. In a Pullman car, the point of least resistance to incoming air, when there are no screens in the windows, is apt to be at the ends of the car, and in this fact there lies a danger, since the odors from the smoking room and saloons are liable to be drawn into the body of the car. This only could be prevented by the use of ventilators having a force exhausting directly from these end compartments, greater than the force due to the combined action of all the ventilators in the body of the car. This feature is a more serious consideration in the day coach than in the Pullman car, since the saloons are not so much isolated from the body of the car, and since the additional end door leakage, and the increased opening and closing of the doors by trainmen, are more apt to cause the movement of air to be toward the middle of the car, than from the middle toward the ends. This objectionable movement of air can be controlled by the use of properly located and correctly proportioned ventilators, and the feature is only mentioned as one to be avoided.

The relation of the strong exhaust ventilator to the heating and ventilating of the Pullman car is a difficult matter to analyze; since the conditions to be met, especially in a sleeping car with the berths made up, are necessarily very complicated. The principal trouble with the sleeping car in the winter time, when the train is moving, has always been to avoid an excess of heat and a lack of ventilation in the lower berths, and a lack of heat and an excess of ventilation in the upper berths. In the summer time, the ventilation of the lower berth is improved somewhat by the use of the window screens, and most of the complaint is due to the conditions when a car is standing at a terminal. The application of the exhaust ventilator to a sleeping car not having special air intakes will not be very effective in relieving the overheated condition of the lower berth in cold weather; but it should improve the heating of the upper berth by drawing a greater proportion of the heat up along the windows and around the upper berth inside the curtains, instead of allowing the most of it to be absorbed in the lower berth, and to pass outside the curtains to the cold aisle and thus escape through the ventilators. The exhaust ventilator also prevents cold draughts from entering the deck sash, which draughts are often so objectionable in the upper berths, and in doing this it should further facilitate the heating, and at the same time it should diminish the excessive ventilation of the upper berth. The ventilation of the lower berths is doubtless improved to some extent by the increased air movement induced behind the curtains by strong exhaust ventilators in the upper deck. This ventilation might be still further improved by connecting a portion of the ventilator to a duct extending down through the walls of the car to the lower berth. It is the opinion of your committee that, as a whole, the general conditions of heating and ventilation of the sleeping car have been improved by the introduction of the strong exhaust ventilators.

The Garland ventilator, as now being applied by the Pullman Company, is constructed upon the aspirator principle, and its entire function is to draw the air from the car. The arrangement of the ventilator ducts and the force of the outgoing air largely eliminates the possibility for smoke, cinders and rain to enter the car through the deck, which is a serious objection to the ordinary deck sash arrangement. The addition of the central duct to this ventilator is the latest development in the direction of an increase of its exhausting power. As now constructed it is a simple and efficient exhausting arrangement and a further description in detail is unnecessary. It is thought that a partial vacuum in the car could be created to almost any degree that might seem desirable, by a sufficient application of a device of this sort; but this partial vacuum, in any other than a Pullman car, will in all probability prove to be more of a harm than a benefit. In a sleeping car at night, a strong exhaust seems to be an advantage and may prove to be a necessity as an assistance to an indirect heating and ventilating system.

The Central Railroad of New Jersey uses a ventilating system, which is a modification of the purely exhaust methods as used

by the Pullman Company, in that an air intake as well as an exhaust, is provided by a combination ventilator. This ventilator has been in operation above five years on the above railroad, where it has been developed in connection with the Automatic Ventilator Company. This latter company has patents controlling the use of this device.

This ventilator is arranged to be substituted for the regular deck sash; or, in cases where it is desired to have an opalescent or other decorative inside sash as a part of the interior finishing of the car, the ventilator can be arranged outside of the sash, and so constructed that the opening of the deck sash will open the ventilator. The device also can be arranged to extend through the car roof, and may be adapted to a car with any design of upper deck. The general arrangement of it is always the same, and consists of two openings or ducts extending into the car, each about 4 by 6 inches in size, with a deflector located between them and extending outwardly at right angles to the panel through which the ducts pass. The proper shutters, screens and other details are provided for controlling the device, and for the exclusion of dirt, cinders and rain. The end of the deflector is bent so as to scoop the air into the forward duct and to exhaust it from the rear duct. Some of the tests show that about 100 cubic feet of air per minute enters the intake side of one ventilator and 116 cubic feet is drawn out of the exhaust side, while running at speed. Tests are now being made to determine the extent that the air is changed in the lower part of the car. A considerable difference in temperature between the outgoing and the incoming air, as has been shown by the numerous tests already made, would seem to indicate that an effective circulation is maintained down through the body of the car. A panel ventilator of this kind has been constructed to take the place of a screen in the lower berth of a sleeping car, the thought being that the occupant could manipulate it to admit air to the berth, or to exhaust it from the berth, as he might desire.

The report has thus far included a description of three distinct systems or principles of car ventilation. The first one is a balanced intake and exhaust system in which the air is warmed before it enters, and must pass through the body of the car before it is exhausted. The second is either a combination admission and exhaust deck-sash arrangement, or, in its later developments, is strictly an exhaust system without any special intakes, in which case the air enters wherever it can and is drawn to the upper deck from all parts of the car. The third system is a combination admission and exhaust arrangement located in the upper deck, with a special ventilator arranged to force and to regulate the air circulation. The first system involves the indirect method of heating, while in the other two arrangements the air is heated by radiators after it is in the car. All other arrangement in use are modifications or combinations of these principles, except the forced-draught or fan system.

The principal argument in favor of the direct method of heating is that fresh, cold air directly from the outside is more invigorating than it is after the life is taken out of it by passing it over heating pipes. Another argument is that passengers desire to see the deck sash open, and that this in itself makes them think they are getting good ventilation. While there may be some weight to the latter argument, they both seem to be misleading in not making a distinction between the heating and the ventilating of a car. Heating does not mean ventilation, nor does ventilation mean heating; since a stifling hot car may be well ventilated, and since a car kept at exactly the proper temperature may not have any ventilation at all. Most of the complaints made by the traveling public are the results of an improper heating of the cars rather than an insufficient change of air in them; not that the ventilation is less at fault than the heating of the car, but because differences in temperature are much more easily and quickly felt than is a lack of ventilation. A passenger can stand a little cold air for a few minutes, as when relieving an overheated car; but when a considerable amount of air is required continuously for any length of time in order to provide the necessary change of air for good ventilation, the committee believes that it must be warmed before it is introduced into the car by some kind of an indirect heating system.

It is the opinion of the committee that, for a given amount of air movement through a car, this air can be heated more satisfactorily and with less steam by the indirect method, than it can by the direct method, on account of a better circulation being maintained around the steam pipes by the indirect system; therefore, it would recommend that the indirect method of heating be used for all new equipment, and for such present equipment as it is practicable to change from the direct to the indirect system. For such coach equipment as it is not expedient to change to the indirect system of ventilation, the committee suggests that extended experiments be made with combination admission and exhaust ventilators located in the upper deck.

Many authorities on ventilation claim that the down-draught system is the only one that should be used for buildings, while others state that the warm air should be admitted near the floor through as many openings as possible, and taken out at the ceiling. An argument in favor of the down-draught system is: that carbonic acid (CO_2), being heavier than air, falls as it is exhaled; also that the breath is exhaled in a downward direction, which assists the falling tendency, and therefore the carbonic acid should be taken out at or near the floor. Another argument is, that the only way to prevent perceptible air currents, is to introduce warm air overhead and allow it to spread uniformly under the ceiling and then to diffuse equally all through the room, rather than to introduce it at the floor and allow it to rise to the breathing line in currents which carry with them dust and microbes from the floor. It is hardly probable that the carbonic acid as exhaled is sufficiently heavy to cause it to fall, since it is usually at 10 to 15 degrees higher temperature than the surrounding air, nor would the addition of about 4 parts of carbonic acid to 10,000 parts of air be likely to counteract the rising tendency of the comparatively large body of air with which it was mixed. However, while this is entirely theoretical, it is the possibilities of actual application that govern, and on this account it is doubtful if the down-draught system could be applied satisfactorily to any type of passenger car. The committee does not recommend the down-draught system of ventilation for any kind of passenger equipment.

It is generally conceded that a forced-draught system is not necessary for the usual equipment in regular service. With reference to special service equipment, such as dining cars, private cars, and certain sleeping cars, the committee believes that a proper forced draught or blower system is, in some cases, necessary and very desirable, as an addition to the regular methods of ventilating these cars. A sleeping car that stands at a terminal in the summer time from 9 P. M. until after midnight to receive passengers, should certainly have some auxiliary means for forcing ventilation, which could be used until the car leaves on its trip. It should be possible to keep a few cars in this kind of service, and to equip them with a blower or an exhaust fan system that could be used in connection with the ducts of the regular indirect heating and ventilating system of the car. These ducts should lead to each lower berth, and the system might be arranged, either to blow fresh air into the berth or to exhaust the vitiated air from it. The committee does not believe that the fan or blower system would be warranted for all regular equipment, since it would be too expensive to install, and since it could not be maintained in good condition by the ordinary attention that it would receive from the porters and train crews.

Some claims are made that the dropping window would allow cool, fresh air to be admitted to the car over the heads of the passengers without striking them directly, and that such an arrangement would have somewhat the same good effect as the dropping of a window in a house to allow vitiated or overheated air to pass out. The committee does not believe that this arrangement would be satisfactory for a car window, as, at best, it would be useful only in mild weather, and would be more objectionable than the open deck sash in cold weather. The incoming cold draught might not strike the person sitting next to the window, but, as it would descend in the car, it would be very objectionable to the passengers sitting farther back. A constant opening at the upper part of the window would be too low to give much relief to an overheated car, and it would create undesirable draughts and cross-currents around the heads of the passengers in cold weather. In warm weather the passengers wish to have the window entirely open and the sash out of the line of vision; so that, in this respect, it does not make any difference whether the sash is raised or lowered.

Some claims are made that the present screen arrangement in the lower berth is good enough, since in any event the porter would usually be asked to make the necessary adjustments before the passenger would retire. This may be true, but the screen arrangement does not allow the occupant to close the window during the night if the berth becomes too cold, or to have a screen inserted if the berth becomes too warm. An easily operated window would place the ventilation of each berth in the control of the occupant.

Various arrangements for window ventilation might be applied. A rolling screen might be attached to the window so that it would close and open with the window. Another arrangement would be to place the regular screen under one sash, and to have the other sash balanced and the fixtures so arranged that it could be opened or closed to whatever extent the occupant of the berth might desire. Another means of ventilation, and one which would not require the use of a balanced sash, would be to use, instead of the usual screen, a ventilating panel of the "Automatic Ventilator" type, having screened openings which could be used to admit or to exhaust air, and which could be opened or closed at the discretion of the occupant of the berth. A proper manipulation of such a device should give better results than do the plain screen openings as now used. Very fine screens would necessarily have to be used on the intake side of such a ventilating panel, on account of the extra movement of air into the berth, which would tend to bring in with it an additional amount of cinders and dust. Still another method for ventilating the lower berth would be to extend a short duct through the walls of the car from each lower berth to a venti-

lator on the roof or under the car located in such a way that one ventilator would be provided for each lower berth or for each two adjacent berths. The openings into the berths might have a register or shutter which could be operated by the occupant, and the ventilators and ducts could be constructed to admit or to exhaust the air or possibly to do both.

The committee recommends that experiments be made with the view of ventilating the lower berth of the sleeping cars, either by means of a balanced window, a ventilating panel, or by a series of ducts and ventilators; such devices to be in addition to the regular heating and ventilating system of the car, and to be used at night when the berths are made up. It further recommends that extended experiment be made with these window and auxiliary arrangements in combination with the strong exhaust ventilators as now used.

The committee believes that it is altogether practical to modify the present sleeping car equipment in such a way as to provide, under the ends of each lower berth, an opening for fresh air that can be controlled by the occupant. Such an arrangement might require some additional radiator pipes, and it might prove desirable to carry a branch of the heating duct to the aisle between each berth and the pillow boxes, in order to admit the warm air to the body of the car in the day time. These ducts could have registers in the ends of them, which should be closed at night, since it would not be desirable to lead warm air to the aisle, only to be wasted through the ventilators in the upper deck. The closing of these branch registers at night and the regulating of the registers under the berths by the occupants, would allow all the heat to be retained in the heating system and to be sent along and delivered to the various berths as might be desired. Your committee realizes the difficulties that might be experienced with any ventilating and heating system, in which the exits and entrances for air are thus allowed to be opened and closed promiscuously. However, it does not seem that this opening and closing of the places of admission would alter, to any great extent, the total amount of air that would pass through the car, but would simply facilitate the distribution of it to the parts of the car where it was most desired. It seems, then, that the fundamental requirement for a sleeping car with the berths made up, is an opening under the lower berth for freshly warmed air in the winter and for cool air in the summer, located in such a way as to allow a distinct movement of air and good ventilation behind the berth curtains. Such openings under the berth for fresh air, even without any means of manipulating them by the occupant of the berth, should give much better results than does the present ventilating arrangement of the sleeping car.

The committee recommends that extended experiments be made, with the view to modifying the existing sleeping car equipment, so as to provide openings under each end of the lower berth; these openings to be controlled by the occupants of the berth, and to be used to admit warmed air in cold weather and cool, fresh air in moderate weather. For new equipment, it further recommends a similar arrangement built into the car and applied in a substantial way, with all the requirements and accessories of a thoroughly complete indirect heating and ventilating system.

Some claim that there should be as good a ventilating system in light suburban, steam or electric equipment as in any other. The argument is, that these cars usually carry more passengers than any of the other equipment, and therefore, they need as much, if not more, ventilation. This is true as far as the needs of ventilation are concerned; but it is not necessary to provide a large part of this air by the ventilating system, since it is usually furnished by the continued opening and closing of the doors. In such service as does not involve the frequent throwing open of the doors for the exit and entrance of passengers, which is often the case in the winter, on certain suburban railways, the car should have a thoroughly efficient indirect heating and ventilating system, the same as other equipment in long distance service.

A well ventilated space, according to the best authorities, is one that may be entered by a person from the outside, without the person being able to detect any of that odor which is characteristic of badly ventilated spaces. There is always a certain small proportion of carbonic acid in any outside air, which many tests have shown to be between 3 and 4 parts in 10,000 parts of air; and it has been found by careful analysis, that it is just possible to detect the characteristic odor mentioned, when the natural 4 parts of carbonic acid in the air has been increased by 2 parts of carbonic acid from human beings. A space, then, is well ventilated when it does not contain more than 6 cubic feet of carbonic acid to 10,000 cubic feet of air. It is thought very undesirable to breathe air containing 7 to 8 parts of carbonic acid, and to be injurious to stay any length of time in a space containing 10 parts of carbonic acid in 10,000 parts of air. In this connection it may be of interest to state that offices often contain 8 parts of carbonic acid, crowded opera houses and meeting halls, 14 to 18 parts, and crowded street cars as high as 22 to 23 parts of carbonic acid in 10,000 parts of air. The tests made by the M. C. B. committee in 1894, show in 10,000 parts of air, 11 to 22 parts of carbonic acid in a sleeping car, 6 to 15 parts in a chair car, and 10 to 21 parts in a suburban coach. These high figures are hardly attained to-day, with the improved ventilating methods and the better attention that these matters now receive.

Tests have proven that the average person, such as rides in our cars, gives off six-tenths of a cubic foot of carbonic acid per hour. Sixty persons in a car would therefore exhale 36 cubic feet of carbonic acid, which amount would require 180,000 cubic feet of fresh air per hour to dilute it so that the air in the car would not contain more than 6 parts of carbonic acid in 10,000 parts of air, the theoretical requirement for good ventilation. This large volume of air equals 3,000 cubic feet of fresh air per person per hour, which amount to the committee seems to be too great to pass through a closed car by any practicable methods.

In solving the car ventilating problem, the amount of air which should pass through a car is usually limited by the amount that can be heated, rather than by the amount as determined by theoretical calculations. The Pennsylvania experiments proved that 90,000 cubic feet of air, or half the theoretical amount, could be passed through the car by the methods used, but that only 60,000 cubic feet of air could be heated properly in zero weather. This amount, therefore, which is equal to 1,000 cubic feet of fresh air per person per hour, or a complete change of air in the car once every four minutes, has been taken as the basis for their system of ventilation. These figures have been accepted by many others as a conservative and very fair basis for good car ventilation; and, since this amount has been found very satisfactory and has stood the test for more than ten years with very little complaint, this figure can be accepted generally as a basis, until a better one is established. At the same time, it may be thought desirable for larger cars and for certain kinds of service, to have a still greater movement of air through the car. This the committee believes can be accomplished with either the direct or indirect systems, by the addition of more hoods or ventilators on the roof and more steam pipes or radiators inside of the car. However, when the good results that have been attained with the present figure are considered, there seems to be a point beyond which it hardly seems necessary to go, both from the standpoint of good ventilation and of economy. It also recommends that a minimum of 1,000 cubic feet of fresh air per person per hour be used as the basis for car ventilation until such a time as another figure can be determined to be a better one.

The carbonic acid test, as mentioned in connection with the Pennsylvania system of ventilating, seems to be about the only accurate way to analyze the various conditions of the air in a passenger car, and the committee recommends the general use of this method.

The best place to admit warm air into a day coach seems from the latest developments to be through pipes, opening at the aisle under each seat. These pipes should connect with a double duct, arranged for distributing and heating the air. The lower duct should provide a free, unrestricted passage for the entering air, so that it is allowed to be distributed along the length of the car at the same time that it is being admitted to the heating duct above it. This allows all the air about an equal contact with the heating pipes, and distributes it effectively throughout the length of the car. If the incoming air was required to travel the length of the car in the duct occupied by the heating pipes, neither the heating of the air nor its distribution in the car would be satisfactory.

The removal of air from the car has been the cause for frequent experiments. Coaches having the indirect system of heating have been fitted up with a large number of ventilators, and also with a comparatively few. It was found with twenty ventilators on a car, that the front ones made more vacuum in the car than could be supplied by the regular intakes at the floor, and that perceptible currents of air were drawn down through the rear ventilators, thus causing the back part of the car to become cold. This difference of temperature at the two ends of the car was eliminated by closing some of the ventilators, which change seemed to prove that the intakes and exits in any system should be very nearly equal in order to obtain the best results.

The committee recommends that the warmed air from an indirect heating system be introduced at or near the floor for all classes of equipment, and be exhausted at the roof at a less rate than it enters; also, for all new equipment, that separate air and heating ducts, with openings between them and to the outside air, be arranged along the length of the car on each side. It also recommends for existing Pullman equipment, that extended tests be made for the purpose of determining the best methods for providing an ample opening for fresh air to enter through a heater box under the berths and for admitting warmed air from heat ducts into the car.

Any car can be heated readily, if it is not ventilated. This is economy at the expense of health, since it only requires a very small amount of steam to heat a car, if the air is shut up and not allowed to get out. Moisture in the air is a very essential element in good ventilation, since even pure air is very objectionable when thoroughly dried out. This moisture is usually furnished in good proportions with the outside air admitted to a car by

an indirect heating and ventilating system; but it quickly disappears when the air is retained in a heated car for any length of time. It is easy and cheap to heat confined air, but it becomes a more expensive and a more difficult problem to heat the large quantity of air that must flow through a closed car to furnish good ventilation; or, in other words, to heat the continuous current of fresh air that must be driven through the car and wasted at the ventilators at the rate of 1,000 cubic feet per person per hour. This is health economy at the expense of money, and the price paid may be taken as the extra coal and steam consumption necessary to properly heat this continuous volume of air that passes into the car and out through the ventilators. The volume of air is large and necessarily moves rapidly. This requires a large heating surface and a proper splitting up of the currents as they pass over the steam pipes. No amount of heating surface or steam pressure will be sufficient to heat the car, if the air currents short-circuit around the steam pipes into the car and are not divided and retained long enough in contact with them to absorb the heat. Ventilation would be furnished in any event, but the car would be cold with a high steam pressure in the heating pipes. It is on this account that the mechanical construction of an indirect heating and ventilating system, including the size and arrangement of all the parts, is of much greater importance than is usually supposed. The system may be a success or an utter failure, depending entirely upon the arrangement and the size of the various parts. Thus the necessity will be seen for determining separately, by careful and extended experiments, the details of the heating and ventilating system for each type of car.

The committee recommends that the piping, ducts and openings of an indirect heating system be proportioned and arranged in constructing new equipment so as to furnish sufficient warmed air for the required ventilation of the car; and that, in cases where a satisfactory temperature cannot thus be maintained in severe weather, auxiliary radiators of sufficient size be located inside of the car near the door, or at some other convenient point.

SUMMARY OF RECOMMENDATIONS.

A.—An indirect heating and ventilating system should be used in all new equipment, the air being introduced preferably at the floor and exhausted near the roof.

B.—Ample openings for fresh air should be provided under the lower berths of sleeping cars.

C.—A slight excess pressure or balance of pressure should be maintained inside of a car when the windows and doors are closed, in order to exclude incoming draughts at the windows and crevices. This can only be accomplished by driving the air into the car a little faster than it is drawn out, and means that the movement of the air must be made to pass through the car, largely by driving it in, rather than by drawing it out by means of strong exhaust ventilators.

D.—An ideal system would be one in which the pressures were balanced and the amount of air passed through the car was entirely independent of the speed of the train. From this it follows that the most efficient exhausting device is not necessarily the desirable one to use if its size must be so reduced to prevent overpowering the inlet when running at speed, that the car is almost bottle-tight when at rest. In other words, an exhauster which will act efficiently as a chimney as well as an exhauster, is to be preferred to an exhauster alone, however efficient the latter may be.

E.—Exhaust ventilators, designed for the purpose of completely controlling the movement of air in a car, should be used only for existing Pullman equipment, until it is possible to change this equipment to embrace the advantages of the indirect system of heating and ventilating. The best results from a ventilator with a strong exhaust is obtained in the sleeping car at night, at which time, on account of the enclosed berths, it may be found necessary to resort to the strong exhaust method in order to make an indirect heating and ventilating arrangement sufficiently effective.

F.—Sleeping cars in such service as requires the cars to stand at terminals during a considerable portion of the night, should be specially fitted with an auxiliary forced-draught ventilating system, in addition to the regular ventilating system of the car.

G.—Air should be admitted to and exhausted from a car without its being perceptible to the passengers, and it should not pass through the car in decided draughts when the car is closed. The entering currents, therefore, should be admitted so as not to come in direct contact with the passengers.

H.—A minimum of 1,000 cubic feet of fresh air per hour per passenger should be furnished for good ventilation.

I.—Ventilating tests should be accompanied by a test for carbonic acid of air taken from different heights and from different parts of the car.

J.—The thing most desired in the heating and the ventilating of a car, as well as in the keeping of the seats and general interior clean and comfortable, is to shorten the season during which there is a tendency to open the car windows. This season should have a tendency to be shortened as the conditions of heating and ventilation are improved. The later in the spring that there is a desire on the part of the general traveling public to throw open the windows, and the earlier in the fall that there is a tendency to close them, the more comfortable is the closed car, and therefore, the better the conditions of ventilation and cleanliness. This shortening of the open car season, then, may be taken as an indication of development and progress.

Subjects.

Committee—W. E. Symons, chairman; Wm. Forsyth, H. LaRue.

The committee on subjects for the year 1908-1909, after making thorough and in some cases repeated inquiries from individual members and railway clubs for suggestions indicating subjects for committee reports, has met with the usual results in that very few replies were received. Among these, however, is one which seemed to be of more than usual importance, and we quote the substance thereof as an introduction to this report. This communication is from a prominent railway officer.

"In looking over the subjects assigned to committees by the Association, it seems to me that the matters of greatest interest are very well covered by the standing committees, and the subjects assigned to the special committees are entirely too important to endeavor to settle them definitely between conventions. It has been my feeling that for some time too much work has been undertaken by the Association to be disposed of in a convention lasting but three days, and that either the number of subjects should be decreased or the time of the convention increased. There has not been, in my opinion, a sufficient amount of discussion on the floor of the convention of some of the reports."

The committee not only concurs in the suggestions and criticisms embodied in the above quotation, but would strongly urge that the Association give serious thought, not only to the number of subjects, but the time allotted for their consideration, and acting on these suggestions in the preparation of our report we offer only three subjects for consideration in 1909, in connection with those which are left over from the 1908 convention:

First.—Standard structural shapes for steel freight and passenger cars.

Second.—Standard tests and specifications for car bolsters and definite location of side bearings. The side bearing location to have special reference to the top member or section of truck bolster.

Third.—To recommend as a standard a universal interchangeable steam hose coupler. This committee to specify contour, or outlines, more completely than the present recommended practice, so that these couplers shall be really interchangeable.

Brake Shoe Tests.

Committee—W. F. M. Goss, chairman; George W. West, B. D. Lockwood.

Frictional Qualities of Shoes Submitted.—The committee reported that during the past year five shoes have been submitted by railway companies. Four were sent by Mr. J. F. Walsh, representing the Chesapeake & Ohio Railway Company, and one was sent by Mr. William Garstang, representing the Cleveland, Cincinnati, Chicago & St. Louis Railway Company. These shoes were tested for frictional qualities under the specifications of the Association. The C. & O. shoes were tested upon a cast-iron wheel only, while the C., C., C. & St. L. shoe was tested both upon a cast-iron and a steel-tired wheel. Three of the five shoes tested upon a cast-iron wheel more than met all the requirements of the Association's specifications; two failed to do so. The one shoe tested upon a steel-tired wheel proved satisfactory so far as the mean coefficient of friction is concerned, but developed an abnormally high rise in the coefficient of friction at the end of the stop.

Wearing Qualities of Shoes Submitted.—The four shoes submitted by Mr. Walsh were subjected to a wearing test under a program similar to that employed by the committee in its preliminary investigations which were reported last year. In reporting these results, the committee drew attention to the fact that, as yet, there is no specification governing tests of wearing qualities. The significance of the data must be judged in the light of the other tests made during the year as given below.

THE RESEARCHES OF THE YEAR.

A Review of the Work of Past Years.—It will be remembered that the Association has definite specifications covering the frictional qualities of brake shoes, and that the work of the committee, during recent years, has been confined to testing shoes under these specifications. The effect of this work has been to stimulate interest in the brake-shoe problem, and to make of record information concerning the action of shoes on both cast-iron and steel wheels. The fact that most shoes recently tested have met the requirements of the Association's specifications, may be accepted as evidence that its work has been effective in improving the friction of shoes sold to railway companies. Two years ago attention was called to the need of information con-

cerning the wearing qualities of brake shoes, and under authorization from the executive committee, initial steps were taken to establish tests which would serve as a measure of wear. The report of last year (see AMERICAN ENGINEER, July, 1907, p. 282) was devoted almost exclusively to a discussion of methods and to the presentation of results obtained from fifteen different shoes when exposed to wear under a definite program. The results, which were obtained by exposing the shoe to wear under a single set of conditions only, showed great variation in the wearing qualities of the several shoes tested. The purpose of the committee during the present year has been to throw light upon this question. To this end arrangements were entered into with the authorities of Purdue University to extend the work along the lines of last year's investigations. Out of the fifteen shoes dealt with in last year's report, there were nine presenting sufficient material to serve under the program of the present year. These shoes are described and illustrated in the report of last year.

The Schedule of Tests.—Each of the nine shoes has been tested both upon a cast-iron wheel and upon a steel-tired wheel; first, when applied under a lighter pressure than that employed last year, and second, when applied under a heavier pressure than that employed last year. Also since the tests last year were upon cast-iron wheels only, the program of that year has been repeated upon the steel-tired wheel. In the actual working out of the program, each shoe was tested under a normal pressure of 1,080 pounds and 4,152 pounds on a cast iron wheel and under pressures of 1,080, 2,808, and 4,152 pounds on a steel-tired wheel. The cycle, as controlled by Gear B, was used for the tests under pressures of 1,080 and 2,808 pounds, and that, as controlled by Gear A, was used for the heaviest pressure, 4,152 pounds, this change being necessary to give the shoe sufficient time to cool between applications. When the cycle is controlled by Gear A, the shoe is in contact with the wheel during 150 revolutions, and is out of contact during the succeeding 1,450 revolutions, the shoe being applied once during each 1,600 revolutions of the wheel. When the cycle is controlled by Gear B, the shoe is in contact with the wheel during 190 revolutions, and is out of contact during the succeeding 610 revolutions, the shoe being applied once for each 800 revolutions of the wheel. The speed in all cases was equivalent to twenty miles an hour. A summary of results is presented graphically by Figs. 1 and 2.

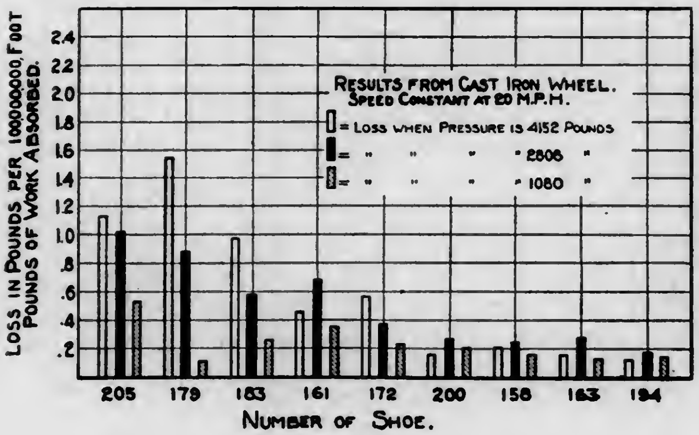


FIG. 1.

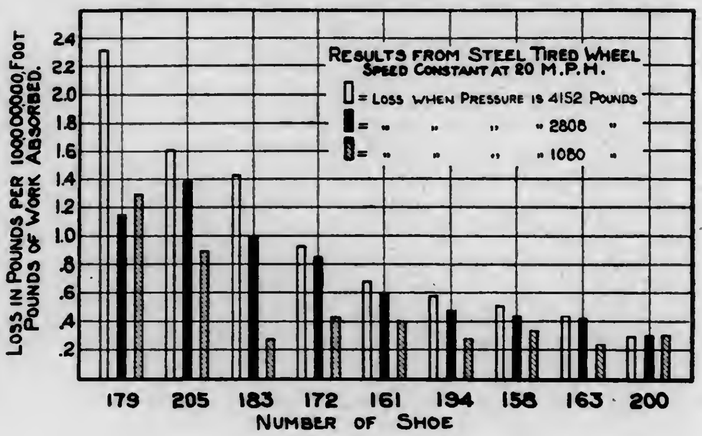


FIG. 2.

Conclusions Concerning Wearing Qualities may be drawn from results presented as follows:

(a) The shoes tested present great variation in the wearing qualities, the ratio between the poorest and the best shoe being as great as 1 to 4.

(b) The relative resistance to wear exhibited by different shoes is somewhat affected by the severity of the application. Of a series of shoes, the one which suffers least from wear at light pressures may not be the one which suffers least under a heavy pressure. Variations of this sort are, however, of small value, and if standards of performance are not too minutely defined, they may be neglected.

(c) Within limits employed by the committee, whatever may be the pressure, the results clearly distinguish between the slow wearing and the rapid wearing shoe.

(d) All shoes tested wear more rapidly on a steel-tired wheel than on a cast-iron wheel. In general terms it may be said that for the absorption of a given amount of work, the wear upon steel-tired wheels is twice as rapid as upon cast-iron wheels.

(e) The results attest the value of the insert shoe. The work of this year was chiefly confined to shoes of this type because the solid shoes had been worn out by the tests to which the series had previously been subjected. (For facts concerning solid shoes, see report of 1907.)

(f) It is noteworthy that the four shoes showing least wear, 158, 163, 194 and 200, on both steel and cast-iron wheels, are all insert shoes, and that all practically meet the Association's specifications as to frictional qualities. (For statement of frictional qualities, see report of 1906, AMERICAN ENGINEER, August, 1906, p. 315.)

Concerning Limits of Allowable Rate of Wear in Brake Shoes.—It is not the purpose of the committee to attempt at this time to frame a specification governing the wearing qualities of brake shoes, though the data presented seems to supply a satisfactory basis for such a procedure. We suggest, however, as a matter for further deliberation, the following qualifications:

(a) The tests designed to determine the wearing qualities of brake shoes be run under a constant brake shoe pressure of 2,808 pounds.

(b) That the cycle of operation be 1,600 revolutions, 150 revolutions being with the shoe in contact with the wheel, and 1,450 being with the shoe in release.

(c) That the peripheral speed of the test wheel be twenty miles an hour.

(d) That under the conditions stated, a shoe should develop for each pound of metal worn away, 350,000,000 foot-pounds of work in contact with a cast-iron wheel, and 200,000,000 foot-pounds of work in contact with a steel-tired wheel.

A specification framed along these lines would pass four out of the nine shoes tested for service on both cast-iron and steel-tired wheels.

Future Work.—The committee believes that the work of the present year leaves two questions open which should be settled beyond doubt before a specification governing wearing qualities should be adopted. These are: (1) A confirmation of the general conclusions based upon the work of the present year; and (2) investigations which will disclose the effect of different brake shoes upon the wheel. With reference to the confirmation of the results of the present year, it would seem wise that not less than fifteen newly selected representative shoes be tested, the program of operation being identical with that employed this year. The results of such tests added to those now available would give a volume of data sufficient to permit limits to be set defining performance, which would be safe and reasonable. The importance of determining the effect of the shoe upon the wheel becomes apparent when the possibility of a shoe showing a high resistance to wear, which may, in fact, be protected at the expense of wear upon the wheels is considered. In discussing this matter last year, the committee expressed its regret "that no measure has yet been made which will disclose the wear of the wheel under the influence of the shoe." To secure such a measure, it will be necessary to have a balance of sufficient capacity to weigh the wheel and of such delicacy as to indicate differences of weight as small as 1-500 part of a pound. No such balance is now available at the laboratory.

Cast Iron Wheels.

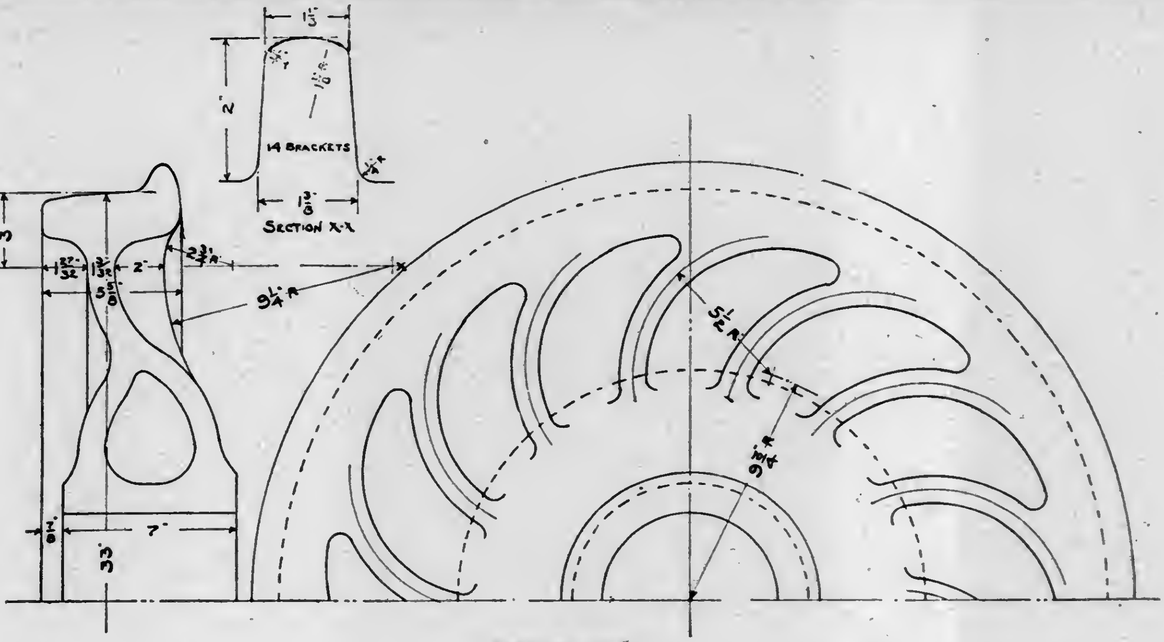
Committee—Wm. Garstang, chairman; A. S. Vogt, H. J. Small, W. E. Fowler, R. L. Ettenger, R. F. McKenna.

The standing committee on cast iron wheels reports the following outline of work accomplished since the 1907 convention:

The recommendations of the committee, in its report for 1907, having been submitted to letter ballot and accepted as an entirety by the Association by affirmative vote on each and all of the recommendations, has limited the committee in its work during the past year to suggested additions, alterations and revisions pertaining to the subject, as follows:

WHEEL DEFECT AND WORN COUPLER LIMIT GAUGE.

Now appearing on M. C. B. Sheet 12, and showing three slots for gauging worn wheel flanges, has been recommended for revision as shown on WC-1908-3 with two slots for gauging worn flanges, for the following reasons: The worn coupler and wheel defect gauge, as presented to the Association in 1907, in which 1-inch, 1 1-16-inch and 1⅛-inch slots for gauging worn flanges was shown, has, on account of the ⅜-inch radius used, been criticised for the reason that the fillets at the throat of

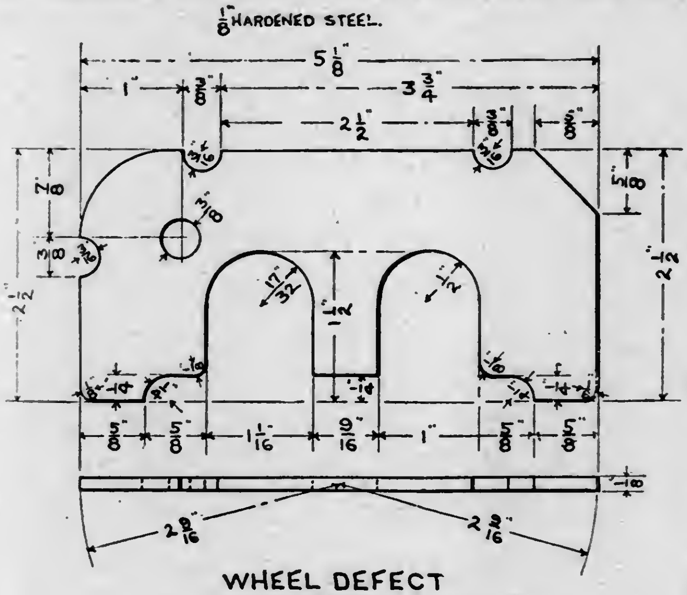


SHEET WC-1908-5.

worn wheels on which this gauge would be used, differ from the radius on the gauge, thereby preventing the latter from properly seating in the throat and resting on the tread, which results in the gauge not being applied perpendicularly and renders the uniform condemning of wheels an impossibility, notwithstanding that the 3/8-inch radius recommended by the committee is very much closer to the actual fillet in the throat of worn wheels than the radius used on the M. C. B. gauge, which was standard prior to the committee's report.

This gauge has been further recommended for revision in the elimination of the 1⅛-inch wide slot for condemning wheels under 100,000 pounds capacity cars.

The committee, in investigaitng both points above referred to, are unanimously of the opinion that both are well taken and



WHEEL DEFECT AND WORN COUPLER LIMIT GAUGE.

they hereby present Sheet WC-1908-3 and WC-1908-4 (not reproduced), showing a proposed new gauge and method of using it to cover the above points, and which it is possible to use in condemning worn M. C. B. standard wheels alike, notwithstanding whether they have the standard flanges in vogue up to 1906 or the strengthened flange of wheels cast under the standard of 1907.

SHAPE OF BRACKETS OR RIBS.

The present "M. C. B. Recommended Practice" for cast-iron wheels as shown by Sheet "J," which requires fourteen brackets supporting the tread and flange at the back face of the wheel adjacent to the single-plate portion, has been criticised for the position of the brackets, which it is claimed does not follow good foundry practice, and also for their shape, which it is stated, permits unequal strains to be set up in the wheel when cooling. Attention having been invited to these details by Mr. Muhlfeld, the committee, after investigation, is unanimous in its opinion that both are well taken, and hereby presents Sheet WC-1908-5 as covering the desired changes.

The attention of the committee has been directed to the fact that none of the cuts published in the proceedings show in detail with necessary dimensions the contour of the tread and flange for steel tires. The suggestion has been made that M. C. B. Sheet A of recommended practice be revised to show in detail with all necessary dimensions the contour of the tread and flange for steel tires, and the title of the sheet altered to include "Tread and Flange for Steel-tired Wheels." The committee is of the opinion that this should be done, making the same correspond to the contour of the wheel tread and flange (from the outside of the tread to the point of the flange only) shown on M. C. B. Sheet A of recommended practice and now used for cast iron wheels. Action on this point should be taken by the Association, as it is beyond the province of this committee to include it in its recommendations.

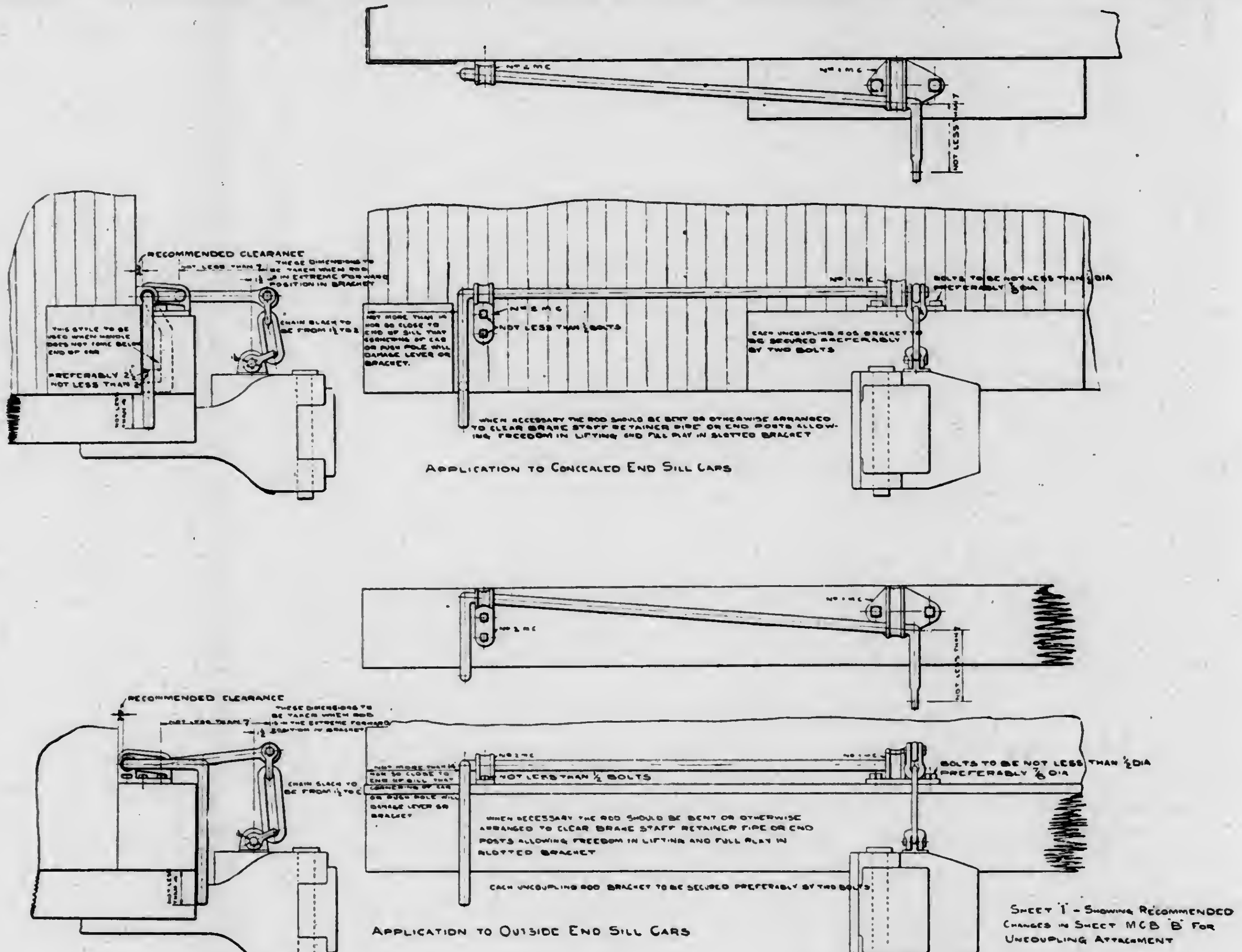
In concluding its report to the Association in 1907, the committee recommended that a service record of the performance of the new wheels be maintained by the members of this Association, for a sufficint period of time to determine what the wheels would do under the increased wheel loads and mileage, so that, if it was desired by the Association to adopt a guarantee, that the actual performance of the wheels could be used in determining what the guarantee should be. After one year's experience with the new wheels, the committee is of the opinion that at least the leading railroads of this country have complied with this request and that there is now sufficient data in the hands of the individual members that can be used by the committee in framing a proposed guarantee, provided the Association votes that one be framed.

Tests of M. C. B. Couplers.

Committee—R. N. Durborow, chairman; G. W. Wildin, F. W. Brazier, T. H. Curtis, F. H. Stark.

The executive committee referred the following subject to the standing committee on tests of M. C. B. couplers: "The investigation of the cause of broken links and clevises, bent uncoupling rods, and to submit a design of uncoupling rod to obviate these troubles."

An examination was made of several thousand uncoupling attachments and a careful and detailed investigation of 1,764 of this number as regards design, application, condition, maintenance, repairs and operation. This was conducted on five railroad systems, and as both foreign and home cars were inspected it covers practically all classes of cars offered in interchange, as well as all kinds of attachments. The results are tabulated on Sheet 3, patented devices not being included in these statements. Four main styles of uncoupling attachments for M. C. B. couplers are found, namely, single-end rods on concealed end sill cars, single-end rods fastened to front of end sill on projecting end sill cars, single-end rods fastened on top of end sill close to body on projecting end sill cars and double-ended rods. Attention is directed to certain particulars brought out in the investigation shown on Sheet 3. The general design, application and maintenance of some uncoupling attachments is not altogether satisfactory, for example, 22 per cent. of the rods will not operate the coupler knuckle throw, and 11 per cent. will not raise the lock to the lock-set position, 18 per cent. have un-



SHEET I.

coupling rods with center arm only three to six inches long, and 17 per cent. have a chain slack as much as from three to seven inches; split links and "S" hooks combined average 12 per cent.; more than one-half of the brackets are applied with lag screws instead of bolts and 71 per cent. of the links and 74 per cent. of the clevises are of smaller size than the recommended practice, which calls for ⅝-inch links and clevises. The style of rod fastened to front of end sill is the least efficient, while, in general, the single-end rod on concealed end sill cars and the single-end rod on back of end sills give better service. Besides the data contained on attached sheets, a large number of uncoupling attachments were found having loose lag screws, rods binding on brake staffs, retainer pipes, ends of car, etc., and with the handle improperly located.

Answers to a circular letter sent out showed that excessive slack in draft rigging is largely responsible for broken links and clevises and for bent rods, but this condition is seldom found on steel and steel underframe cars equipped with high capacity spring or friction draft gears. It is found largely in the older and lighter equipment having wooden draft arms with single springs and three-bolt draft stops bolted to side of draft timbers and not gained into them, which are not maintained in proper repairs for service under varying conditions.

In this connection it should be noted that the release rigging on these older cars are designed for use with the couplers without lock-set in the coupler head, but lock-setting was accomplished by supporting the release rod on a shelf provided on the end bracket, which required a neat adjustment of chain. This design worked out very well for the couplers in use during that period when chains had sufficient slack, as the draft arrangements were adequate for the weight of trains handled. Now, however, these same cars are having the modern lock-setting and knuckle-throwing types of couplers applied, requiring as much as six inches lift, using the same length arm on rod and same chain connection which was used when springs were subjected to 25,000 pounds pull. Whereas, now, two engines are frequently used exerting a tractive force of from 70,000 to 80,000 pounds, while the stresses in trains due to rough handling have been accurately measured and found sometimes to exceed 600,000 pounds. This condition is bad enough in the type of draft rigging noted above, but the worst conditions are present on cars equipped with the American continuous draft gear. There are now, however, relatively few of the latter in service, and these are being replaced with improved types of draft gears.

Rods.—On some of the older types of couplers the lock does not operate in a central vertical plane and the rod should be changed when an M. C. B. standard coupler is applied, but this is not often done and the old rod causes certain difficulties in the operation of the coupler. On box cars with concealed end sills, uncoupling rod is liable to be made inoperative when end of car is forced outward; on all forms of uncoupling rods and particularly double-ended rods requiring more than two bearings this trouble is rather pronounced and is aggravated by often using such brackets that place the rod close to the siding so that slight bulging of the end interferes with operation of rod. Proper care is not taken to offset or locate rods a sufficient distance from brake staff, retainer pipe, end posts, etc., to provide the necessary clearance for operation. Occasionally bends made to clear these obstructions allow insufficient movement of rod to properly throw the knuckle. Double-ended release is preferred by some; however, it is a fact that these double rods are frequently bent and are liable to become totally inoperative. Bent rods attributed to shifting loads are frequently damaged by coming in contact with rods on coupled cars when the slack in the train is bunched. Rods with long center arms located on face of end sill, with draft gear in release position, on which the eye of rod is more than two inches ahead of eye of coupler lock are liable to interfere when coupler horn is against striking plate, especially when draft attachments and end sills are in a worn condition. A rod with the handle on the side of car is undesirable on account of interference with the use of the sill step and its liability to become bent or broken in such an exposed position.

Brackets.—The design and attachment of brackets have an important influence on the operation of the uncoupling attachment. The usual brackets allowing but little play to the rod are a source of inoperative uncoupling attachments. The committee believes that the best form of center bracket is one having a slot which gives the rod about 3½ inches longitudinal

INVESTIGATION OF UNCOUPLING ATTACHMENTS
SHOWN IN PERCENTAGES

Kind of Rod	Draft Gear	Number Examined	Brackets Secured by: Center, Bolts	Center, Lags	Outside, Bolts	Outside, Lags	Size of Links: 1/4"	3/8"	1/2"	5/8"	3/4"	Split Links	"S" Hooks	Size of Clevises: 3/8"	1/2"	5/8"	3/4"	No Clevis	Will Not Operate: Lock Set	Knuckle Throw	Length of Center Arm: 1" to 3"	3" to 6"	6" to 9"	9" to 12"	12" to 15"	Amount of Chain Slack: 0 to 1"	1" to 5"	5" to 7"	Relative Position "A" Lift Pin Eye, "B" Lock Pin Eye: "A" More than 5" Behind	"A" 1" to 5" Behind	"A" 1" Ahead to 1" Behind	"A" More than 1" Ahead	Bent Rod
Single End Rod on Concealed End Sill Cars	Single Spring	319	20	80	1	99	3	22	41	9	4	15	6	17	60	16	4	3	11	17	1	15	78	8	1	44	43	13	2	27	48	23	20
	Tandem Spring	295	49	51	19	81	1	15	54	20	3	5	2	11	62	22	4	1	11	19	0	10	79	11	0	40	42	18	2	15	64	21	12
	Twin Spring	167	37	63	15	85	1	18	58	11	3	8	1	8	75	13	2	2	8	19	6	9	72	18	1	42	42	16	1	15	68	18	18
	Friction	33	61	39	49	51	0	30	61	3	0	10	0	12	75	0	3	10	6	10	0	0	76	21	3	61	21	18	0	12	67	21	24
	Total	814	36	64	12	88	2	19	50	13	3	10	3	13	65	16	4	2	10	18	1	10	76	12	1	45	41	16	2	18	59	21	13
Single End Rod Fastened to Front of End Sill	Single Spring	210	27	73	3	93	3	16	48	11	10	9	3	13	59	15	10	3	16	24	3	10	26	5	0	43	42	13	5	12	45	38	15
	Tandem Spring	128	55	45	31	69	1	12	62	17	2	4	2	9	66	19	2	4	15	38	1	29	60	10	0	48	43	9	0	10	68	22	12
	Twin Spring	125	36	64	27	73	0	8	73	4	2	11	2	4	80	10	2	4	12	18	1	12	80	7	0	35	51	14	2	8	71	19	6
	Friction	25	76	24	76	24	0	0	48	40	0	12	0	0	68	24	4	4	8	12	0	60	40	0	0	36	40	24	4	4	60	32	4
	Total	488	39	61	21	79	2	12	58	12	5	8	3	9	67	16	6	2	14	25	2	44	47	7	0	42	44	14	3	10	59	28	11
Single End Rod Fastened to Back of End Sill	Single Spring	15	80	20	20	80	0	40	53	7	0	0	0	13	80	7	0	0	13	20	0	0	87	13	0	40	60	0	13	13	54	20	27
	Tandem Spring	52	60	40	46	54	0	15	65	14	0	4	4	4	67	23	4	2	6	17	0	4	52	19	25	25	50	25	4	12	67	17	11
	Twin Spring	90	93	7	92	8	0	8	87	3	1	1	0	0	78	22	0	0	13	34	0	0	7	26	67	16	52	32	0	11	70	19	12
	Friction	145	97	3	99	1	1	4	62	15	12	4	2	0	62	22	13	3	8	50	0	1	6	43	50	43	38	19	1	10	68	21	23
	Total	302	88	12	84	16	1	9	69	10	6	3	2	13	68	22	7	2	10	26	0	1	19	32	48	31	46	23	2	11	68	19	17
Double End Rod	Single Spring	47	15	85	2	98	2	32	54	11	9	6	0	13	51	26	10	0	4	15	0	6	81	13	0	51	29	20	0	36	49	15	23
	Tandem Spring	80	50	50	38	62	0	10	54	32	0	4	0	0	61	38	1	0	4	32	0	6	73	13	6	41	43	10	2	10	68	20	25
	Twin Spring	55	42	58	18	82	0	30	55	6	0	6	3	21	58	15	0	0	12	18	0	6	66	30	6	40	40	20	0	6	70	24	12
	Total	160	38	62	25	71	1	26	48	22	2	5	1	9	57	29	5	0	6	20	0	16	73	16	5	47	38	15	1	17	65	19	23
Grand	Total	1764	46	54	28	72	1	15	55	13	4	9	3	9	65	18	3	3	11	22	1	18	58	14	9	40	43	17	2	15	61	22	14

SHEET 3.

travel and is attached to the car by bolts. The outside bracket on wooden cars is generally attached by lag screws and, as it is usually necessary to remove these lags to straighten bent rods, it is felt that bolts are preferable. There are two or three brackets on the market allowing the rod to be removed without removing the bracket itself, which is a good feature, especially for yard repairs. On steel equipment the brackets are usually attached by bolts and no trouble is experienced. Occasionally they are attached by rivets, which is undesirable, because it is either necessary to straighten the rod on the car or to cut off the rivets, unless the brackets are of that type mentioned above.

Chains.—Short chains is a condition not confined to the old wooden cars, but is frequently seen on steel and steel underframe cars of modern construction. One reason for this is that the coupler manufacturers usually provide a chain of fixed length which is being used for all designs of rods and car end constructions, instead of arranging the length of chain with reference to the end construction, type of rod used, travel of gear, etc. This defect is noted more frequently on cars equipped with couplers having the floating type of lock, which are generally provided with a chain so that a clevis only is necessary to connect lock to rod. This difficulty has been avoided in some instances by using an extra clevis or a clevis provided with two holes. It is recommended that these chains must have an eyelet above locking-pin hole so that the recommended links and clevises can be used. This should avoid the use of split links and "S" hooks.

"Kinked chain" is a defect usually found on the floating lock type of couplers, the links wedging in coupler head so that repeated jerking on the rod fails to dislodge them, making adjustment necessary. Insufficient attention is given to this matter, and it is felt that, were the links for this purpose secured and well-fitted to locks, less trouble would be experienced. Couplers having a long single-piece lock require close adjustment of uncoupling attachment to prevent binding and consequent heavy duty on the release rod and chain. The use of a large number of links of small chain should be discouraged, as they break easily, and when one link breaks it is usually replaced by an "S" hook or split link. It follows that the best practice is the use of two heavy malleable iron clevises cored for 3/4-inch pins connected by a single heavy wrought iron or malleable link.

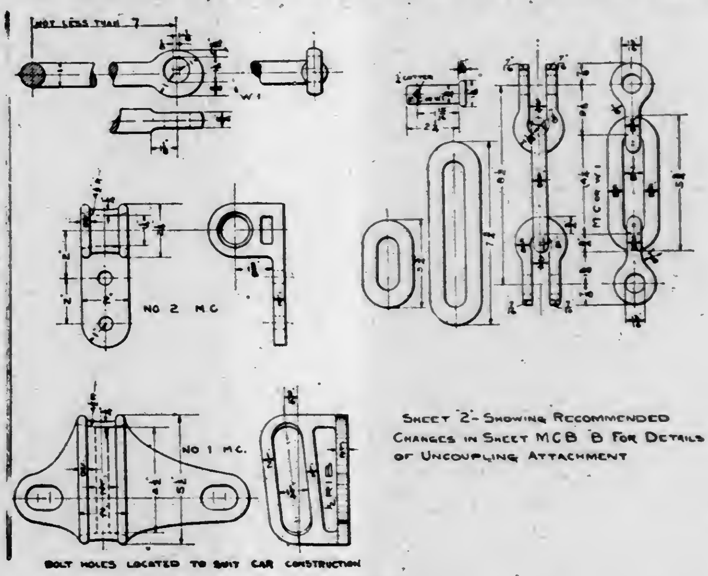
Improper or light material both in original construction and in repairs is a large factor in the increased number of bent uncoupling rods and of broken links and clevises; the use of split links and "S" hooks instead of clevises and bolts instead of pins, contributes to a large number of failures. There is little excuse for these practices on the shop tracks and in the yards; such points should be provided with a supply of standard links, clevises and pins to insure cars being repaired with standard material. Attention is directed to the fact that certain coupler companies are furnishing clevises which use the 1/2-inch instead of the recommended 3/4-inch pin. The use of bolts should be discouraged, as the nut works off, making uncoupling attachment inoperative. Large cotter pins are also used instead of the recommended 3/4-inch pins.

There are other causes for bent rods and broken links and clevises, many of which are not chargeable to design or maintenance of uncoupling attachment, but solely due to carelessness of those handling cars. Cars cornering in yards is the cause for a great many bent rods, as is also the careless use of push poles.

Interference with Passenger Car Buffers.—From the answers received there is apparently little trouble from the buffers of passenger equipment making uncoupling attachment of freight equipment inoperative when these two classes of cars are coupled together. It is not the practice on many roads to run freight equipment cars in main line passenger service, but where this is done, either the buffers are removed, or some special release device is used. The use of the two classes of equipment together is largely confined to branches where the passenger equipment is of the older type, and, having the two circular buffers, little difficulty is found in the way of interference.

Proposed Uncoupling Attachment.—It is the belief of the committee, based on the replies to the circular of inquiry and on the investigation made, that considerable trouble from inoperative attachments is due, first, to not taking into consideration, when designing, all the various elements necessary for efficiency in operation and repairs; and second, a lack of proper attention to maintenance after application. It is believed that for all classes of cars and for all couplers which come under the M. C. B. Standards a single ended rod properly designed is the most suitable arrangement not covered by patents that can be used. Acting on this, changes are suggested in M. C. B. Sheet B, which it is thought will overcome the defects in design and reduce to a minimum the troubles incident to improper maintenance; this is shown on Sheets 1 and 2.

The special feature of this uncoupling attachment is the slotted center bracket, which has been in use on a number of roads



Sheet 2—Showing Recommended Changes in Sheet MCB B for Details of Uncoupling Attachment

SHEET 2.

for some time, and very few cases of bent rods, etc., are found on cars so equipped. By placing the rod back on top of end sill or head block a longer arm is obtained, which gives sufficient lift with ample slack in the chain, and by using a sloping slotted bracket the rod projects 1 1/2 inches in front of coupler lock, which is about the best position for an efficient lift. The slotted bracket allows the rod to slide back 3 1/2 inches and avoids interference when slack of train is bunched.

The handle shown should preferably project below end of car or be bent as shown by dotted lines on Sheet 1, in order to protect the operator's hand.

The present Recommended Practice Sheet B, shows a chain 8½ inches long with one 5¾-inch link; the proposed recommended practice shows two additional links 3¾ inches and 7¾ inches long, respectively. By using one of these three links, therefore, a chain 6½, 8½ or 10½ inches long is obtained, which should fit all cars and M. C. B. couplers. These links should avoid the use of split links, "S" hooks and other temporary repair devices now very common. The arrangement as a whole is applicable to all types of cars, and if properly applied will largely obviate present troubles. Only a few limiting dimensions are shown on the drawing, as the others must be adapted to each particular class of car; but the dimensions for center arm, chain slack and position of lift pin eye should be carefully adhered to.

Side and Bottom Operating Couplers.—There are a number of types of side and bottom operating couplers in service to a limited extent on several roads, some of which present good features. The committee has also examined some types of these couplers in process of development at the works of the manufacturers, and the best that can be said is that they are still in an experimental stage. The main objection that can be seen at the present time is that each coupler requires a special form of uncoupling attachment. On the side operating couplers the rods, bell cranks and pivot points, provided on the coupler head, are liable to be damaged by couplers passing on curves of short radius. On the bottom operated couplers similar conditions prevail with the addition that, in some forms, the uncoupling attachment is secured by drop hangers, which are likely to become damaged by coming in contact with certain designs of bumping posts. Furthermore, a great number of parts are usually required for these uncoupling attachments.

It has been suggested that the specifications should be modified to permit the use of the side and bottom operated couplers. Not long since there was a decided sentiment in favor of adopting one standard coupler, which was found impracticable at that time, and the committee was instructed to continue making the specifications more rigid, with the object of ultimately reducing the number of types of couplers to a minimum, and therefore retaining only those embodying designs which will give both maximum strength and the best operating properties. As a result of this the M. C. B. coupler has been developed to that point where a common standard uncoupling attachment can be used with all types meeting the specifications, and consequently the number of repair parts for both coupler and uncoupling attachment are relatively small. In addition to this the proposed couplers have only been tested in service to a very limited extent.

In view of the foregoing, it is believed inadvisable to open the specifications to admit the use of side or bottom operated couplers until such time as the merits of either one of these can be recommended in place of the present standard, but in order to ascertain the availability of these proposed devices, the committee would suggest that they be given an extended trial by different railroads on cars of their own equipment, preferably on those not offered in interchange.

In view of past experience the committee believes that changes in the recommended practice and standards of the Association should only be suggested after careful deliberation, especially in cases of experimental arrangements, which should be thoroughly tried out before being included in specifications, so as to avoid too rapid changes, which may result in error, and with this in mind the above view of the question is taken.

OPERATION AND CONDITION OF COUPLERS.

With a view of obtaining definite information relative to the operation and condition of couplers in service, the committee made an investigation of about fifty each of the ten most prominent types, and results are tabulated on Sheet 6. The numbers at the top, representing the names of the couplers, are the same used last year, with three additional types, and are arranged in chronological order with the older couplers on the left. No data was taken in cases where the coupler had been fitted with improper parts, such as wrong knuckle pins, or where the uncoupling attachment did not operate properly.

It has developed that when some of the coupler manufacturers changed the contour lines of the couplers in accordance with the standards of the Association, they neglected to fill in the lines of the knuckle contour sufficiently to coincide with the new lines resulting from the addition of metal across the knuckle lugs of the bar, leaving an opening between the knuckle contour lines and the lines of the bar when knuckle is closed. This prevents the point of the mating knuckle engaging the knuckle tail continuously until the lock drops. Another item entering into the mating of couplers is the failure of some coupler knuckles giving a full opening. The point of knuckle should be in a line with the inside of the lugs on bar, which line should be parallel with the longitudinal center line of coupler.

COUPLER SPECIFICATIONS.

A summary of the recommendations which the committee offers to be submitted to letter ballot, to be adopted either as standard or recommended practice, is as follows:

STANDARDS.

1. That 1¼-inch rivets be used for attaching yokes to coupler butts, and that Sheet M. C. B. 11 be changed to conform to this recommendation, showing 1 5-16-inch rivet holes in coupler butts.
2. That the following be added to third sentence of paragraph 5 of specifications for automatic couplers, "and the rivet holes in the butts must be drilled, or if cored, must be broached out."
3. That all new types of couplers put on the market after January 1, 1909, have a dimension of 9¼ inches from back of coupler horn to inside face of knuckle, and that the face or front wall of coupler have a minimum thickness of 1¼ inches, and that a note to this effect be added to coupler drawings on Sheet M. C. B. 11.
4. That the total lift of the locking pin be not more than 6 inches, and that a note to this effect be added to coupler drawing on Sheet M. C. B. 11.
5. That all couplers must have an eyelet for locking device located immediately above locking-pin hole, so that the recommended links and clevises can be applied, and that a note to this effect be added to coupler drawings on Sheet M. C. B. 11.
6. That the pulling test under specifications for automatic couplers be changed to read as follows: "The couplers must stand a steady pull of 150,000 pounds." "A coupler shall be considered as having failed to stand this test . . . if the knuckle has opened more than ⅝ inch. . . ." "Should either or both couplers fail to stand the prescribed test, but both stand 100,000 pounds, another complete coupler or pair of couplers shall be provided. . . ."

OPERATION AND CONDITION OF COUPLERS

	KIND OF COUPLER										AVERAGE
	1	2	6	4	9	8	25	5	23	24	
AVERAGE DISTANCE - POINT OF KNUCKLE TO GUARD ARM	$4\frac{7}{8}''$	$4\frac{13}{16}''$	$4\frac{7}{8}''$	$4\frac{15}{16}''$	$4\frac{7}{8}''$	$4\frac{15}{16}''$	$4\frac{15}{16}''$	$4\frac{3}{4}''$	$4\frac{3}{4}''$	$4\frac{13}{16}''$	$4\frac{7}{8}''$
PER CENT KNUCKLE THROW INOPERATIVE	NOT KNUCKLE THROWING COUPLERS			5	61	35	31	32	11	11	27
PER CENT LOCK SET INOPERATIVE	63	3	2	0	6	6	0	0	0	0	7
PER CENT KNUCKLE TAIL BEARING WORN	4	3	17	36	0	0	5	0	11	0	8
PER CENT LOCK BEARING WORN	0	3	4	16	0	0	0	0	0	0	2
PER CENT PIVOT PIN BENT	4	0	6	3	3	0	0	0	0	37	5
PER CENT PIVOT PIN WORN	2	3	17	7	9	2	0	0	0	20	6
PER CENT PIVOT PIN HOLE WORN	20	12	23	28	9	50	17	4	11	54	23
PER CENT BENT OR BROKEN LOCK	0	0	0	0	6	4	9	4	0	3	3
AVERAGE PER CENT	14	3	10	12	12	11	8	5	4	16	10

SHEET 6.

RECOMMENDED PRACTICE.

1. That drawing on Sheet M. C. B.—B, showing coupler butts, be omitted, as this will be identical with butts shown on Sheet M. C. B. 11.
2. That drawing of uncoupling attachment on Sheet M. C. B.—B be changed to conform to Sheets 1 and 2 attached, and that recommend practice for uncoupling arrangements be also changed so as to conform to this recommendation.

FRICTION DRAFT GEAR.

The executive committee requested the committee on M. C. B. couplers to recommend a standard maximum capacity for friction draft gears, and the most desirable resistance during each ⅛-inch compression, also to report to the value of friction draft gear in reducing damage to cars and their contents. To secure data on the above subject, there was referred to the members a circular of inquiry to which replies from 53 railroads, representing 904,000 cars, were received.

The committee, in sending out this circular of inquiry, realized that the use of friction gear is by no means general, and also that while a number of road tests showing the stresses to which trains are subjected have been made, there is little reliable data which shows the frequency of the high pulling and buffing strains in road service. The whole question is quite complicated, as it should take in the question of the influence of heavy steel equipment with friction gears on the older light capacity wooden equipment with spring gears.

The replies in general seem to be based on the capacity of the gears now on the market, a decided preference being exprssed for a capacity of about 150,000 pounds. At present, the better types of spring gears have a capacity of about 60,000 pounds, and absorb practically no work, the compression being sent back into the train as recoil. The ordinary pulling and buffing forces when train is in motion do not usually exceed 40,000 pounds when train is handled by one engine, but there are shocks due

to engines coupling on trains, yard switching, etc., which are of frequent occurrence and often exceed 100,000 pounds. When there is a lack of attention in gravity yards and brake maintenance and operation is faulty, stresses of 600,000 pounds have been exceeded, and on road brake tests with the maximum poor conditions stresses of 500,000 pounds have been recorded.

In general the car framing, draft gear and attachments should be considered not only for the home road, but also with reference to conditions on roads with which the cars will be interchanged. In case cars are subjected to small stresses, a low-capacity draft gear equal to these stresses is more satisfactory than a high-capacity gear of same travel, as in the latter case there will be more shock transmitted to the car framing, because the small shock is taken up in a short travel in the high-capacity gear. From these considerations 150,000 pounds seems to be a desirable capacity for general service where cars of all types are made up in the same train. Roads handling heavy trains of steel cars loaded with coal, ore, etc., and not interchanging these cars, may find it advantageous to use gears having a capacity of 300,000 pounds or more with the present travel, as experience has shown that on the better class of modern steel cars the attachments are amply strong and the car framing is sufficient in strength to stand severe shocks. It would be inexpedient to make equipment wreck proof, when there is still much to be accomplished in the improvement of braking conditions, such as better maintenance of the brake apparatus and more careful handling by the train crews.

The distribution of work in the friction draft gear is a more important factor than the maximum capacity, for it has been shown by tests that with two gears, one of which has a much higher capacity than the other, the first by reason of its distribution of work transmits more shock to the car framing than does the second, the maximum capacity of the first being 50 per cent. greater than the second. As has been previously stated, the vast majority of the shocks in the train when brake equipment is in good condition and properly handled are not much more than the maximum tractive power of the engine, which on an average is about 40,000 pounds. From this it follows that a friction draft gear should have a capacity of 30,000 to 40,000 pounds in the first 1 to 1½-inch travel, and then the capacity should be increased to a maximum which with present travel it is believed should be from 150,000 to 200,000 pounds. Experience has shown that with much more capacity than the above with the present travel the transition from the preliminary spring action to the frictional operation is not smooth, and transmits severe shocks to the attachments and car framing. Therefore, the results from gears of 300,000 pounds capacity are often less satisfactory than those having 150,000 pounds, assuming the diagrams similar in relation to release.

In this respect, providing there is smooth action in the compression, the friction gear has a unique advantage due to the absence of large recoil, the work being absorbed in the heating and wearing of the friction surfaces instead of being returned to the train, as is the case with spring gears. However, there should be sufficient recoil to release the gears promptly, as some gears have been found jammed and failing to release.

The advocates of increased travel should consider that 150,000 pounds capacity is, in general, sufficient with the present travel when the gear is satisfactorily designed, in view of the fact that the majority of cars with which they run have draft gears of only 60,000 pounds capacity.

No definite figures can be obtained concerning the variation in the cost of maintenance in the draft gear itself comparing the older spring gears with the modern spring and friction types, as the weaker gears, draft attachments and cars themselves are liable to be in more or less worn-out condition. It is found that the modern wooden cars with the improved gears are very seldom shopped for draft gear repairs, but a large proportion of bad order cars are of the older type, and the damage can generally be traced to the weakness of the draft gear. The old single spring having a capacity of often less than half the tractive power of the engine is easily compressed and then transfers hammer-blows to the car framing, resulting in large renewals of springs and attachments.

Renewals to the friction gear have been due to broken casings, springs and occasionally friction blocks, but this breakage has not been a serious factor with the better class of gears, in fact many gears have been found in good condition and with their capacity unimpaired after five or six year's hard service. The breakage of springs is due to heavy loads imposed in a relatively short travel, but even with these springs broken it is found that some friction gears have a capacity equal to that of the twin or tandem spring gears.

The condition of friction draft gears jamming and failing to release is not a general one and has been found in only a few types. The reduction in capacity is due more to broken springs than to wear of the friction surfaces, as it is found in some cases that when the springs are in good shape the old gear has a higher capacity than the new gear, due to the friction surfaces having taken a bearing. The broken casings were found largely in the first gear put on the market and the points of weakness when found were reinforced, so that little difficulty is now experienced in this direction. It is felt that the sticking of gears in compression is due to the combination of insufficient frictional area and too great an angularity in the wedges.

FRICTION DRAFT GEAR TESTS.—To supplement the data furnished by answers received to circular of inquiry relating to a standard maximum capacity and the desirable resistance during each ⅛-inch compression, static tests were made of new and old gears of types most largely found in service. Twenty-seven gears, furnished by different railroads, representing five types, were tested, and of this number nine were new, the others having been in freight car or locomotive service from a few months up to five or more years. Each type is denoted by a letter and

Test No.	Type		Work done inch lbs.	Work absorbed inch lbs.	Work absorbed %	Recoil inch lbs.	Recoil %	Gear closed at –	Total Deflection
1	A	New	163,200	141,000	86.39	22,200	13.61	120,000	2.801
2	A	New	104,000	81,200	78.07	22,600	21.93	90,000	2.793
3	A	New	122,000	100,600	82.46	21,400	17.54	95,000	2.748
4	A	Old	60,000	51,800	86.33	8,200	13.67	60,000	2.361
6	A	Old	126,600	109,600	86.57	17,000	13.43	150,000	2.505
8	B	New	172,000	154,400	89.76	17,600	10.24	170,000	1.903
9	B	Old	102,400	90,800	88.67	11,600	11.33	200,000	1.881
5	B	Old	99,000	82,000	82.82	17,000	17.18	110,000	2.243
7	B	Old	64,000	47,200	73.75	16,800	26.25	85,000	2.363
14	B	Old	232,400	210,600	90.63	21,800	9.37	280,000	2.295
14a	B	Old	151,600	129,600	85.49	22,000	14.51	160,000	2.420
15	B	Old	162,000	138,600	85.55	23,400	14.45	175,000	2.267
15A	B	Old	93,600	75,200	80.34	18,400	19.66	105,000	2.295
12	B_1	New	213,600	191,800	89.79	21,800	10.21	225,000	1.948
12a	B_1	New	159,800	137,600	86.10	22,200	13.90	210,000	1.873
13	B_1	New	302,000	279,200	92.45	22,800	7.55	285,000	2.216
13a	B_1	New	226,600	205,400	90.64	21,200	9.36	235,000	1.708
23	B	New	262,200	230,000	87.72	32,200	12.28	280,000	2.263
24	B	Old	197,700	165,000	88.23	22,000	11.77	290,000	1.748
25	C	New	173,800	144,600	83.20	29,200	16.80	300,000	2.203
26	C	Old	44,200	29,800	67.42	14,400	32.58	160,000	2.103
17*	C_1	Old	105,200	61,800	77.75	23,400	22.25	300,000	2.422
18*	C_1	Old	105,200	78,800	74.90	26,400	25.10	300,000	2.477
19*	C_1	Old	91,200	71,600	78.50	19,600	21.50	300,000	2.435
20*	C_1	Old	134,000	118,600	88.52	15,400	11.48	300,000	2.323
21*	C_1	Old	129,800	117,400	90.45	12,400	9.55	265,000	2.340
22*	C_1	Old	102,600	77,000	75.08	25,600	24.92	300,000	2.434
27	D	Old	40,000	23,800	59.50	16,200	40.50	300,000	1.449
27a	D	Old	65,800	37,800	57.44	28,000	42.56	300,000	2.023
28	D	Old	38,000	23,200	61.05	14,000	38.95	300,000	1.185
28a	D	Old	64,000	39,600	61.87	24,400	38.13	300,000	1.840
10	E	New	145,000	138,400	95.45	6,600	5.55	195,000	3.000
11	E	Old	124,600	118,800	95.80	5,200	4.20	130,000	2.812

*- Passenger type. No. 4 had broken preliminary spring.

Note:-

Test No. 12 on type "B_1 New" was very irregular, the wedges frequently sticking in such manner as to cause very severe shocks when finally their resistance had been overcome. In tests 13, 14 and 15 the gears behaved in much the same way. Tests 12a and 13a are retests of gears 12 and 13. No. 12a is made after five additional complete closures of the gear, for the purpose of smoothing the wedges to relieve the irregularities noted in test No. 12. No. 13a was made after eight additional closures of gear No. 13, made for the same purpose as in the case of gear No. 12. In this case the treatment was only partially successful, since the wedges in wearing down to a smooth surface began to score, thus introducing an additional source of irregularity in the behavior of the gear. No. 27 and No. 28 tests were on rusty gears and on this account the friction surfaces failed to operate properly. Nos. 27a and 28a were tests on same gears with friction surfaces greased.

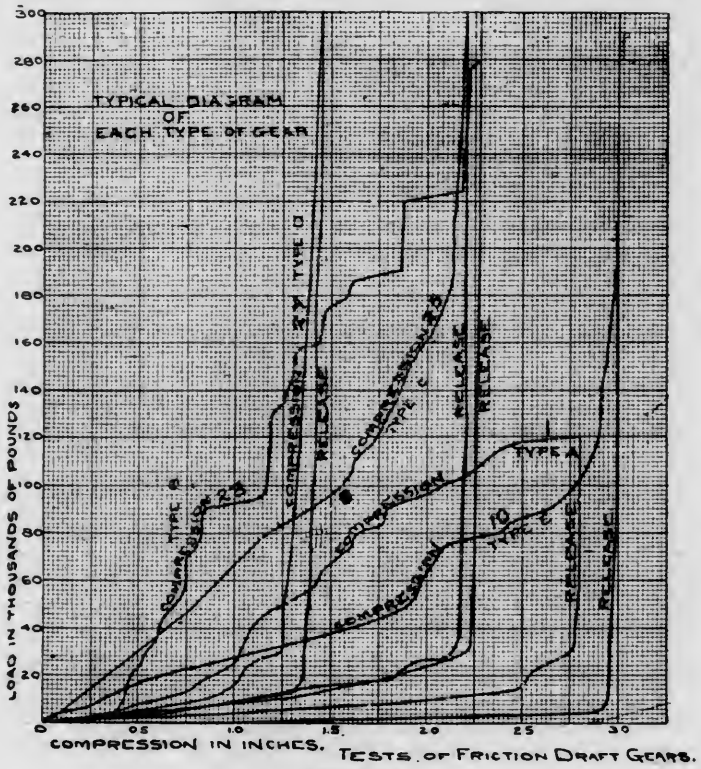
SHEET 16.

in the two types having more than one pattern, the difference is denoted by adding a subscript to the letter. The tests were made on a 300,000-pound screw machine, increments of load being applied in the usual manner and the readings of deflection made until the gear became solid when release was made in increments and corresponding readings taken. These results were plotted, in the usual manner, and computations shown on Sheet 16.

Type "A" is constructed on the parallel friction surface principle, and has been on the market a number of years. Its application is the most extensive of any of the friction gears and it is in general use on a number of roads largely engaged in coal and ore traffic, and has been reported satisfactory. Tests Nos. 1, 2 and 3 are new gears, and 4 and 6 old gears that were on freight cars for a number of years. The gear used in test No. 4 had a broken spring, but with this defect the gear had a capacity equal to that of the better type of spring gears with the additional advantage of only 13.67 per cent. recoil. The gear in test No. 6 shows up well for an old gear, and may be accounted for

by the fact that the frictional surfaces had become well worn. This type of gear decreases in efficiency when casings and springs are broken, but the difficulty from the first cause has been reduced by improving the design. As far as can be learned the gears do not become inoperative by becoming jammed and failing to release.

Type "B" is of the angular friction surface type and the new gear has a very irregular compression line largely due to the rough surfaces and the large angle of the wedges. Attention is directed to tests 12, 13, 14 and 15, and to retest of the same gears under numbers 12-A, 13-A, 14-A and 15-A, as shown on Sheet 16. It is seen that the spring action changes to friction action in about .4 inch, and also on comparing the compression



SHEET 14.

with that of the other gears it will be noted that it is extremely abrupt, irregular and less efficient in cushioning the shock on the car framing than the spring action extended over more travel.

The other gears, types C, D and E, are used less extensively than the foregoing ones and little definite information regarding them is available.

Attention is directed to Sheet 14, which shows a typical diagram for each of the gears. It will be seen that there is a wide difference in the distribution of work between the different gears and it is evident that the results obtained in cushioning the shocks will necessarily vary to even a greater extent, due to influences not exhibited by the diagrams, such as wear of friction surfaces, breakage and set of springs and deformed casings.

In view of the above facts, the committee, while admitting the value of static diagrams in determining certain facts about the distribution of work in friction draft gears, feels that at the present time it would be inadvisable to recommend a standard maximum capacity or to specify how it should be distributed. Were these values now specified within narrow limits it is evident that at the best not more than two types of gears would satisfy the requirements imposed.

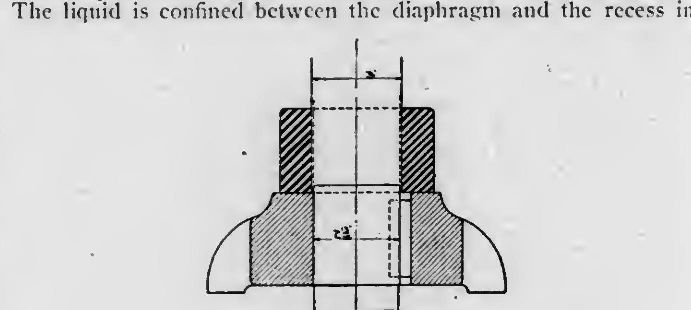
Through the kindness of A. L. Humphrey, general manager of the Westinghouse Air Brake Company, who has devised a method for testing friction draft gears, data of exceeding interest and value has been available. This test consists in dropping a 9,000-pound weight, working between machined guides, a distance varying from 6 to 24 inches. The draft gear is mounted on a standard follower, supported by standard stops secured to channels by eighteen ½-inch rivets. This test gives a general idea of the relative values of the various spring and friction gears in reducing damage to the car framing, due to improper distribution of compression and excessive recoil. Mr. Humphrey has very generously offered to place this apparatus at the disposal of any members of the Association wishing to make draft-gear tests.

The committee has in mind the design of an apparatus embodying something of the above principle, but so arranged as to be applicable to a standard car in order that a close approximation to actual service conditions may be obtained in testing the efficiencies of the various friction draft gears in cushioning the shocks to the car framing. It is also believed that in the event of satisfactory results being obtained from these tests that a standard method of testing friction draft gears may be developed for testing gears on a drop test machine, providing that the conditions on the last mentioned apparatus may be so adjusted as to closely approach those found in the service test, and in this event the test could be incorporated in specifications for friction draft gears, which should be framed as soon as sufficient definite information on the subject has been obtained, and the committee will continue to work along these lines.

COUPLER SIDE CLEARANCE.

As a result of the topical discussion at the 1907 convention on coupler side clearance the executive committee referred this matter to the coupler committee. Railroads who have investigated the subject were requested to send results of their tests, but no data was furnished, as they evidently did not consider these sufficiently thorough to conclusively solve the problem. Several methods of testing were then considered with a view of determining definitely the proper side clearance for couplers on freight equipment cars. No tests have been made, but the following plan is submitted for the consideration of the Association, and it will be carried out during the coming year, if it is approved. A train of steel gondola cars of 41 feet, 11 inches coupled length, equipped with couplers having 5-inch total side clearance, is to be operated on a division having a large number of sharp curves, including some of 13 degrees. By means of iron blocks the side clearance can be adjusted from 0 inch to 5 inches, and it is proposed to measure the lateral stresses exerted by the coupler on the various curves with a recording pressure registering device placed on the end sill of one of the cars. The draw-bar pull for the different side clearances on the curves can be obtained at the same time with a dynamometer car. In this manner the side pressures exerted by the draw bar and the relation of tonnage hauled to coupler side clearance, will be determined. From these results it will be easy to determine whether or not flange wear is increased by limiting the side clearance.

Through the courtesy of A. S. Vogt, mechanical engineer of the Pennsylvania Railroad, and Messrs. William Sellers & Co., Engineers, a drawing of a proposed hydraulic side pressure dynamometer is shown on Sheet 17. The principle of the device is as follows: A single annular diaphragm is used, which is clamped between pieces "A," "D" and "E," and which is loaded by piece "C," which in its turn is attached to piece "B." All of these pieces are in the form of rings. The parts are stayed by thin plates "F," "G" and "H," which are also in the form of rings. The cell is enclosed in a shell fitted with trunnions, and having radial finger-like projections at each end, which form the abutments. The washers, or followers, "I" and "K," are made with similar projections so as to transmit the load to the support. The liquid is confined between the diaphragm and the recess in



SHEET 17.

"A," and this space is connected by means of a small copper pipe to a recording gauge of the Bourdon tube type. The attachment to the coupler and car is shown on Sheet 18 (not reproduced). The desired side clearance can be adjusted by placing blocks inside the yoke connecting the registering device to the coupler. As the space containing the liquid is very small the travel of the piston and consequent lateral play of the coupler beyond the desired clearance will be practically negligible. The calibrations will be made from an initial pressure to avoid any errors due to lost motion. The question of purchase of this dynamometer at the expense of the Association has been referred to the executive committee, and if approved, the committee hopes to furnish some definite data on this subject next year.

ATTACHMENT OF YOKE TO BUTT.

There is some dissatisfaction with the present method of attaching coupler yokes to the butts, but to date no other method has been presented which, in the judgment of the committee, would be an improvement. It has been suggested that additional lugs be cast on the coupler shank to form a pocket for the yoke gibs between these lugs and the coupler butt. The object of the extra lugs is to force the yoke gibs to fit against the coupler butt and thereby avoid placing the rivets in shear. Your committee assumes that it is expected to deal with couplers without machining and to use yokes as they are forged, which necessarily means some allowance from the drawing sizes. The pocket formed on the coupler shank, unless machined, will not be accurate, which also holds true in the case of the gibs on the coupler yoke. Even with good machining it is difficult to obtain fits of one yoke gib in the pocket, and this difficulty is increased as the two gibs of the yoke must be fitted at the same time. If any motion is allowed, to that extent the rivets are subject to shear, and practical application with any workmanship that is likely to be secured within reasonable cost will result in a certain amount of clearance between the yoke and lugs, however placed, and the stress will be placed upon the rivets until such time as they are worn or sheared enough to allow all parts to come into bearing.

Another suggestion is the use of four short rivets instead of two long rivets, the idea being that the short rivets can be better heated so as to completely fill the hole when driven. Experiments have been made along this line, but no decided advantage to offset the additional cost was found. The present standard providing for 1¾-inch bearing top and bottom for the rivets is a decided improvement over the old design of butts, and the main difficulty at the present time is the relatively poor fit of the yoke to butt and the membering of the rivet holes. If more care is exercised in this fitting it will greatly increase the efficiency of the attachment. To further this end the committee is designing gauges for the relative location of the rivet holes to the gib bearing surface on the butt and the similar spacing on the yoke. It is believed, however, that the rivet holes in the butts should be drilled or broached to insure better fitting of rivets, and the committee, therefore, makes this recommendation.

Standard Marking of Freight Equipment Cars.

Committee—R. L. Kleine, chairman; T. H. Russum, W. O. Thompson, C. B. Young, J. F. Dunn.

At the last convention the committee on standards and recommended practice presented a communication from Mr. W. F. Allen, Secretary of American Railway Association, relative to recommendations from Mr. Arthur Hale, chairman of the American Railway Clearing House, in regard to marking cars with standard initials and the suggestion that the initials and numbers should be painted in some uniform place on each car, and not too high. It was also stated that Mr. Hale had taken up the subject of standard initials for marking freight cars with the Association of Transportation and Car Accounting Officers.

The object of this suggestion is to facilitate car checking, particularly at night, the intention being to recommend a uniform location and height for the initials and numbers of cars, and with this understanding the suggestion was approved by the committee on standards, which offered the following additional paragraphs to the section on stenciling cars:

"The initials and numbers of all cars having a superstructure, which will permit, shall be placed about midway between the door and corner post on the left-hand side of the car, and be arranged at a height of 4 feet 9 inches from the rail to the underside of the bottom row.

"It is further recommended that the name of the railroad should also be placed on this end of the car over the initials and number, and that the space at the right-hand end of the side of the car be reserved for the marking showing capacity, dimensions, weight, etc."

In view of the various standards of marking in use by the railroads, many of which possess points of merit, and the fact that the construction of the cars regulates to some extent the location of the marking, the committee is of the opinion that the location of the marking should not be confined within narrow limits, but a recommended practice governing it should allow sufficient latitude to meet conditions and at the same time confine the location so that it will facilitate the work of car checkers, conductors, scale men, inspectors, and others, whose duty it is to take information from markings on cars.

Although the work assigned to the committee was to consider the location of the initials and numbers of cars, it was found that the locations of other markings were so closely allied to those of the initials and number that they have also been included, subject to approval.

With this end in view, the committee submits the following recommendations for consideration:

MARKING ON FREIGHT EQUIPMENT CARS.

1. Freight equipment cars that have a superstructure which will permit should be stenciled with markings on sides of car, in the following order:

Lettering (Initials or Name of Road),
Number,
Capacity,
Light Weight.

This marking is to be located as nearly over the truck as the lettering will permit, preferably to the left of center line of side of car. On box and other house cars where doors slide to the left, the above marking may be placed to the right of center line of side of car. On any other cars where the construction makes it necessary, this marking may be placed either to the right of center line of side of car, or in the center of side of car. The distance from the center line of coupler to the bottom of car number to be normally 2 feet 4½ inches, with a minimum dimension of 1 foot 10½ inches, and a maximum of 2 feet 10½ inches. The spacing of the remaining marking to be as shown on diagram. (Not reproduced.)

This location will place all the information necessary for the ordinary handling of cars in yards, freight sheds and over scales, in such a position that it can be easily read, both day and night, from the ground, platform, or scale, by conductors, scale men, car checkers, inspectors, agents and any other men whose duty it is to take information from markings on cars.

By placing the light weight below the capacity, it will facilitate restenciling this information when necessary at times of re-weighing. Space should be left between the light weight marking and the bottom of car side to allow for restenciling at time of reweighing, as it is impracticable to stencil over the old marks without giving time for body color paint to dry.

In order that the markings may be most effective, the committee suggests the use of 9-inch letters for the name or initials, 7-inch figures for the number, 3-inch letters and numbers for the capacity and 4-inch letters and numbers for the light weight as preferable sizes for this lettering and numbering, although the alternate sizes now given in recommended practice may be used if desired.

2. The ends to show the initials or name of road, car number and light weight, in the upper half of end of car. On box or other house cars having end doors, this lettering should be so located that it will not be obscured when doors are open.

The upper half of end is preferable, as the lower half is more frequently covered by dirt and grease thrown upward by the wheels of the preceding car, which would obscure the marking if placed on this half of car end, and in case it is necessary for a conductor to take any numbers while train is in motion, they can be much more readily seen from the top of car.

The initials, number and light weight on end of car are of paramount importance to scale men, as it enables them to compare the initials and number with the manifest and enter the light weight before the car reaches the scale platform, besides assisting the weigher to set the scales.

3. Flat and low sided gondola cars should show the lettering (initials or name of road), number, capacity and light weight on the side of car in the best available location offered by the construction of the car. Suggestions as to the arrangement of this lettering are shown in the diagrams. (Not reproduced.) When possible, the sizes of lettering and figures should correspond with those used on other freight equipment cars. The end marking on flat cars may be omitted.

It is self-evident that no specific recommendations in regard to location of lettering on flat and low-sided gondola cars can be made, due to the limited available space upon which to place the lettering, in addition to the variation in construction, and it was thought desirable to only specify that the necessary markings should be placed upon the cars leaving the location optional, so that it can be best suited to the construction.

4. Side and end doors should be stenciled with the initials or name of road either on the outside or inside of door. If placed on the inside the stenciling should be so located that it will not be defaced by the sliding of the door.

This stenciling is considered essential to enable railroads to determine the ownership of doors which are lost off.

If the above recommendations meet with approval the present recommended practice relating to the "marking of fast freight line cars" should be dropped, as the proposed arrangement covers all cars.

The committee on standard and recommended practice re-

ferred the three following suggestions, received from members in regard to changes in standards relating to marking of freight equipment cars, to this committee for consideration, and it would report as follows:

STANDARDS FOR STENCILING CARS.

1. It is recommended to discontinue stenciling the words "air brake" on cars, since all cars must be so equipped.

The committee approves of this, inasmuch as the Rules of Interchange provide that "All cars offered in interchange must be equipped with air brakes," and, therefore, the stenciling of air brake on the cars has become obsolete, and we would suggest that this portion of paragraph be dropped from the Standards.

2. It is recommended to omit legend "Do not nail this door," as it is not observed, and, therefore, has no practical value.

While the committee agrees with the suggestion that this is of no practical value, there is nothing in the standards or recommended practice requiring stenciling of car doors "Do not nail this door," and, therefore, has no recommendations to make.

3. It is recommended to eliminate stenciling "A" and "B" end on cars, as it is unnecessary.

The committee approves of this suggestion, inasmuch as the location of brake shaft indicates the ends of car which are equipped with one brake shaft; and the direction in which the push rod travels distinguishes the ends of the cars which are equipped with two brake shafts. Railroads should not be required to place any more stenciling on cars than is absolutely necessary, not so much from the standpoint of first cost as the expense involved in maintaining same.

The committee would call attention to the elaborate advertising on the sides and ends of some cars and would recommend that the practice be discouraged, as it very often involves employing experts in freight repair shops to reproduce the original intricate designs when repairs to siding are necessary.

Pedestals and Journal Boxes for Passenger Cars.

Committee—C. A. Seley (chairman), E. A. Benson, J. J. Tatum.

At the 1907 convention the committee on standards and recommended practice made the following report on the above subject:

"Your committee believes that this box and pedestal could be improved by being made nine inches in width, and suggests that it be referred to a special committee to make recommendations and propose designs."

This has special reference to the pedestal and box for 5 by 9 journal shown on M. C. B. Sheets C and E. The present outside width of the box between the pedestal fits is 8½ inches, which gives but 7½ inches inside width between walls, ½ inch less than on the freight car box of same size. This restricts convenient handling of the sponging, bearing and key, as well as giving too little room for using oil cans.

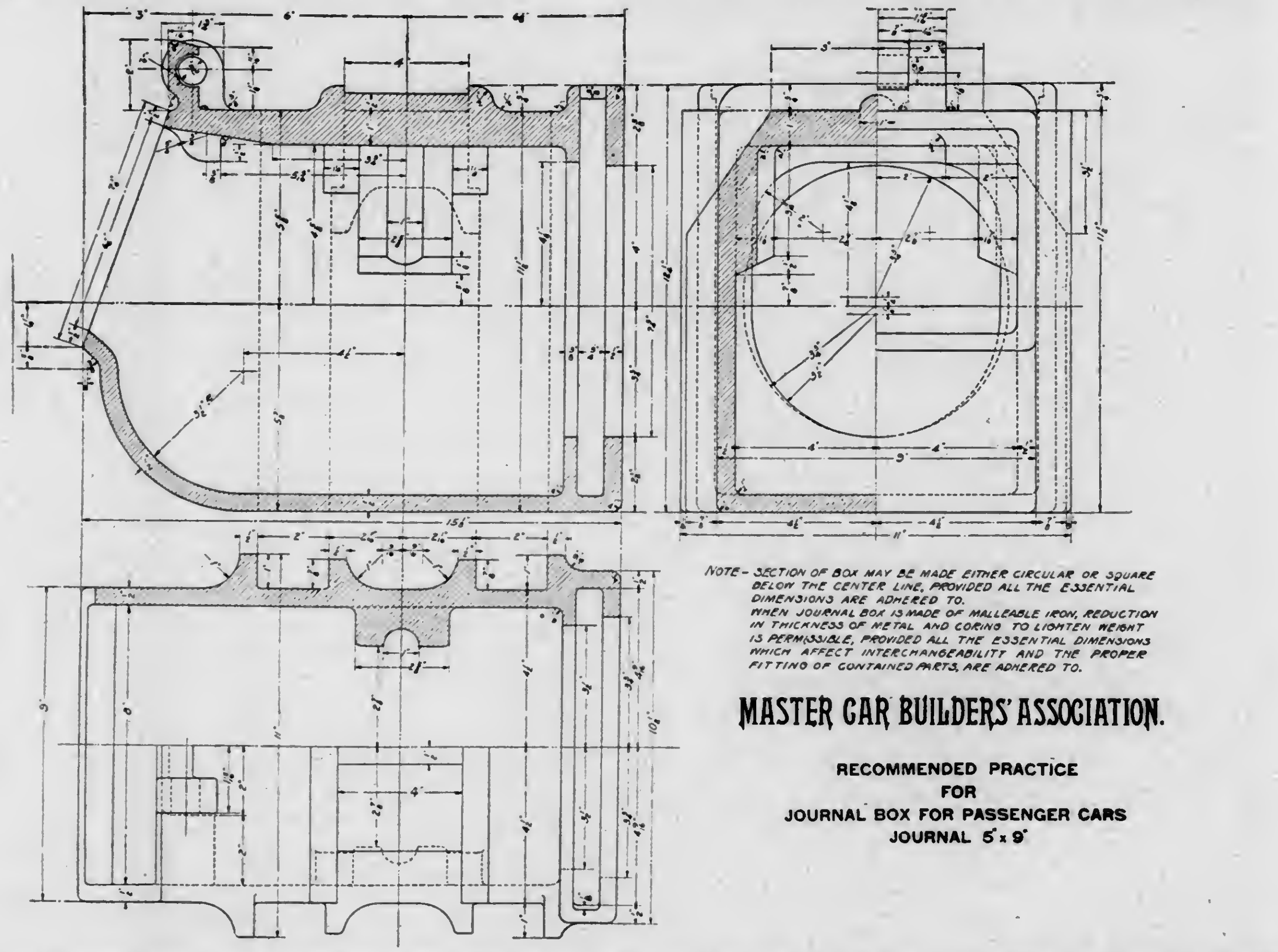
The committee, therefore, presents for consideration a new drawing of the 5 by 9 passenger box, revised from that shown on M. C. B. Sheet C, with dimensions changed to give 8 inches inside width between walls, preserving other essential dimensions.

The drawing presented also includes some other revisions which the committee deems advisable.

Sheet M. C. B.—C shows the top corners of the box chamfered, no dimensions being given. This is for clearance of the equalizer, and the amount of chamfer has been increased both in length and depth to permit stronger equalizer construction.

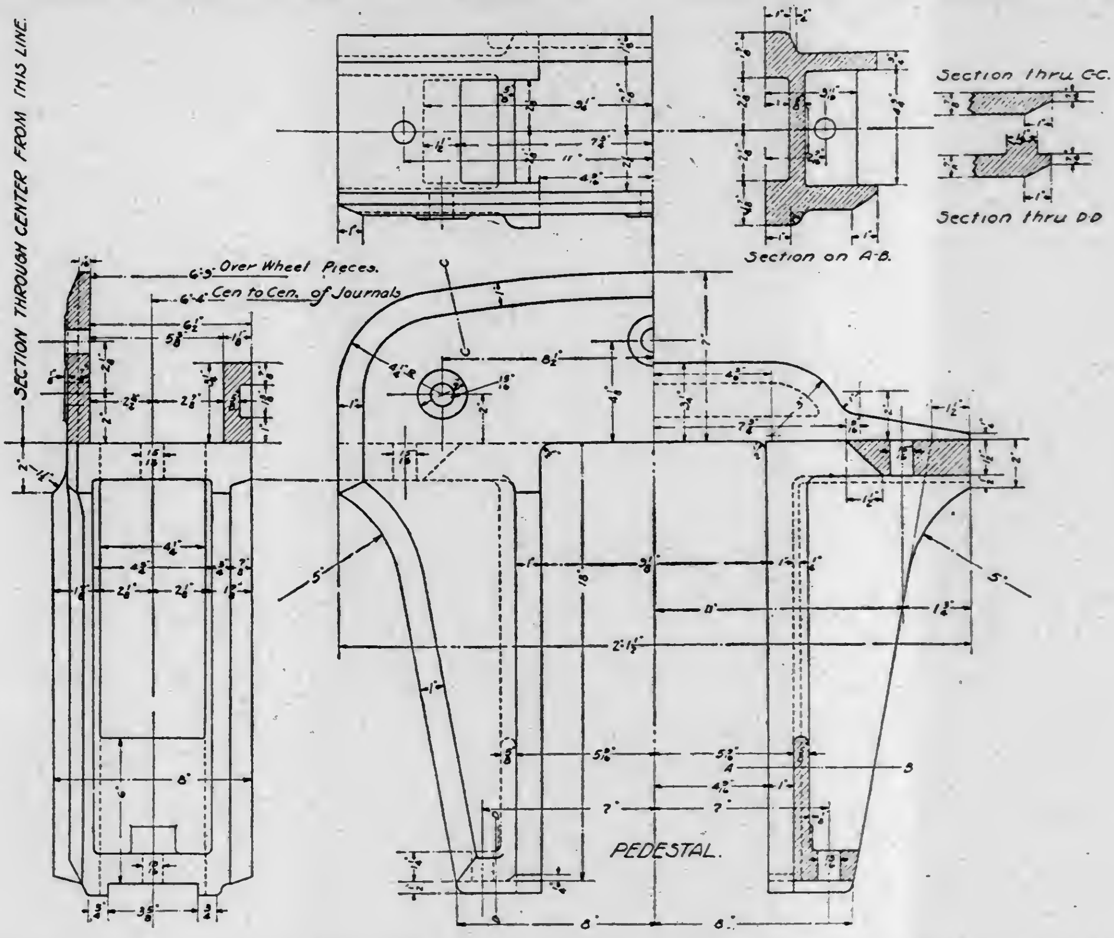
The drawing has also had the end view corrected to show the bottom edge of the lid opening level to agree with the other two views, as well as to make the lid opening of the same shape on all the freight and passenger boxes.

Slightly increasing the clearance between the outside dust guard wall and axle is suggested, and in doing so the depth of the box for oil has only been decreased 1-16 inch. The opening for the dust guard has been therefore increased a like amount to maintain the lap of dust guard on wall, thus better preventing dust getting into the box. The inner dust guard wall has been considerably modified in order to clear the flanges of the journal bearing, but it has been sufficiently retained to strengthen the box at the upper corners.



The committee also offers for approval a new drawing of pedestal for 5 by 9 boxes revised from that shown on Sheet M. C. B.—E increased in width between the jaws from 8⅝ inches to 9⅛ inches to take the box just described, also having revised the location of one of the bolt holes by which the pedestal is bolted to truck wheel pieces in accordance with the practice of some of the larger companies.

We find that many trucks are in use having width over wheel pieces not the same as called for on the drawing, so that offset of bolting flange is not much value as a standard, and as it would complicate the drawing so much to show the offset required for various widths, it is deemed not desirable to make any change in this respect. The spacing of the bolt holes at the bottom which are used for bolting the tie bar has been increased, so as to use square-head bolts. The present spacing necessitates the use of T-head bolts, which are special and not generally as available as square-head bolts.



The committee also suggests removal of the bead or surface ribbing, making the outer face of the pedestal one continuous surface, of proper thickness at the bolt holes and guides and gradually rounding off to the outer edges. This modification does not sacrifice strength nor materially increase the weight, but it does improve the appearance and facilitates cleanliness. The smoother surface does not catch and retain the dirt as on present design, and is more readily wiped.

This drawing shows wearing bearing, as formerly, for 1-inch depth of flanges on boxes.

This committee was also instructed to include in its recommendations designs for journal box and pedestal for trucks using 5½ by 10 inch journals. It does not favor the use of this size journals in passenger service. They are not justified in six-wheel trucks, and when cars are of the length and weight which would require greater axle capacity than is afforded by four with 5 by 9 inch journals, six-wheel trucks should be used.

It finds that very few roads have used 5½ by 10-inch journals in passenger service. If future development should bring about such a requirement, it is of the opinion that by that time the truck construction and material will have changed from present practice and the labor would be in vain, at least so far as the pedestals are concerned.

Side Bearings and Center Plates for Freight and Passenger Cars.

Committee—R. D. Smith, chairman; R. P. C. Sanderson, Alfred Lovell, J. H. Manning.

The committee was instructed:

To review and give synopsis of reports on side bearings and center plates made to the Association in the past, since and including 1900.

To recommend a standard spread, height and clearance for side bearings for freight and passenger cars.

To investigate and report on the relations which center plates and side bearings may bear to derailments.

The first step taken by the committee was to carry out the instructions of the executive committee, to review the previous reports on center plates and side bearings, and a synopsis of the reports presented to the 1900-1-2-3-4 conventions was given.

RECOMMENDATIONS.

Friction should be reduced as much as possible, and as hardness and rigidity of form have a direct bearing on this, and ample strength being important, the committee recommends the use of cast steel center plates for large capacity cars and malleable iron or cast steel center plates for smaller capacity cars.

The committee believes that it is desirable to lubricate ordinary center plates and recommends that this be done at frequent intervals.

Taking into consideration the information which has been received as to the durability of anti-friction center-plates, the committee cannot now recommend their use as the standard practice of the Association, but considers further investigation desirable.

While the resistance of the trucks to turning might perhaps be reduced by placing the side bearings nearer to the center plate than is the common practice, the tendency of the car to roll would be increased.

The committee recommends adopting as standard for passenger cars:

A spread of 88½ inches center to center of side bearings on six-wheel passenger car trucks with outside bearings. A spread of 60 inches center to center of side bearings on four-wheel passenger car trucks. That side bearings on passenger cars be placed just in contact, but carry no load.

The various designs of trucks and bolsters in use, and the tendency to use steel construction, make it impracticable to recommend standard heights of side bearings or their height relative to the height of the center plate on passenger cars.

The committee recommends adopting as standard for freight cars:

A spread of 60 inches center to center of side bearings. A clearance of not less than ¼ of an inch nor more than ⅜ of an inch between upper and lower side bearings when new.

The various designs of trucks, bolsters and steel underframe constructions in use make it impracticable to recommend standard heights of side bearings or their height relative to the height of the center plate.

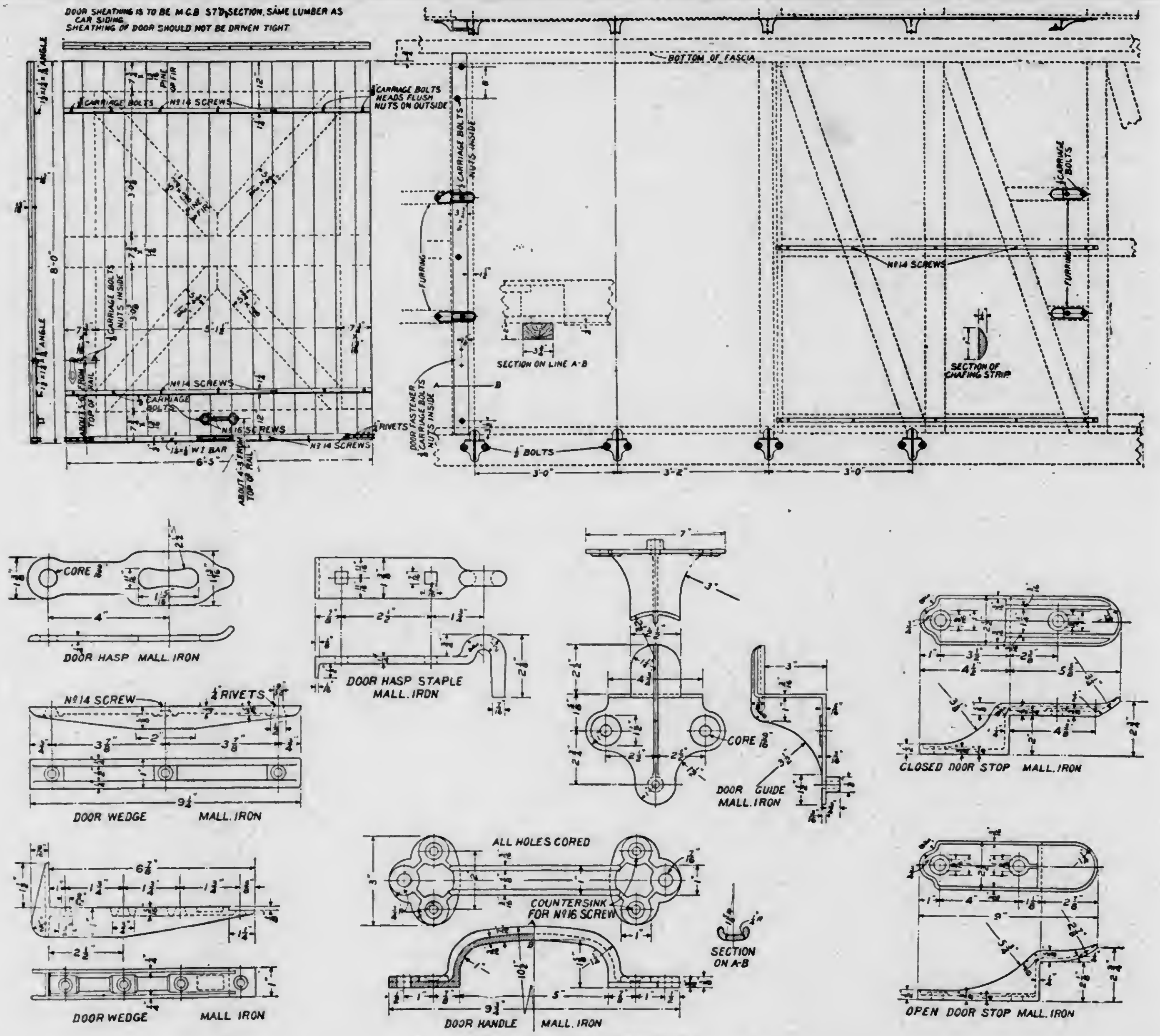
The investigations of the committee warrant them in stating that the use of anti-friction side bearings will reduce flange wear and lessen the probability of derailment.

As it is not proper to recommend as a standard any specific patented device, the committee recommends only, for passenger and heavy capacity freight cars, the use of side bearings embodying the anti-friction principle in any form that insures simplicity and durability to the greatest possible extent.

In view of the importance of tests to be recommended later, the committee does not suggest any change in the M. C. B. standard center plate.

There is evidence that derailments have in many instances resulted from the use of side bearings carrying too great a proportion of the load when used with rigid underframes, and from the binding of improperly constructed center plates and side bearings, which causes the wheel flanges to crowd and climb the rail.

The greatest practical freedom of movement of the trucks



PROPOSED M. C. B. SHEET F.

which allows of their adjusting themselves to curvature and inequality of track is believed by the committee to be of vital importance, not only because there is less probability of derailment, but also because wheel flange wear and the danger from broken wheels is diminished.

The committee therefore calls attention to the importance of this matter and recommends that an appropriation be made for the purpose of conducting further tests, not only of various forms of common center plates and side bearings, but also of different types of anti-friction center plates and side bearings. Tests should be made for the purpose of determining the best location of side bearings.

MINORITY REPORT.

While recognizing the desirability of fixing uniform dimensions for as many parts of cars as possible, I cannot agree to subscribe to the above report, in so far as fixing the distance from center to center of side bearings at 60 inches for freight cars, when the investigation of the committee shows that freight cars are in existence having side bearings located from 48 inches center to center, to 70 inches center to center.

To definitely fix the location of side bearings would, in my opinion, require more time and investigation than the committee has had opportunity to make since the last convention. I have been unable to find that a spread of 60 inches is preferable to a spread of either 48 inches or 70 inches.

D. F. CRAWFORD.

Location of Ends of Running Boards.

Committee—E. A. Miller, chairman; T. A. Treleaven, R. H. Parks, F. W. Chaffee, J. Coleman.

During the year past valuable data has been accumulated and considerable correspondence has been carried on with the members. As difficulty has been found in reconciling the diverging views as to the maximum and minimum allowable projection of running boards, the committee recommends that it be continued for another year, to give the subject further consideration.

Box Car Doors and Fixtures.

Committee—C. S. Morse, chairman; J. A. McRae, O. M. Stimson, J. P. Young, W. Percy.

The committee has made a new drawing for M. C. B. Sheet F, which shows a side door, door stops, bottom guides, chafing strips, wedges, hasp, hasp holder and handle; also, the location of the door stops, guides and chafing strip.

The door has been designed for an opening six feet wide, and height suitable for a car of the inside dimensions approved by the American Railway Association and the recommended practice of the M. C. B. Association. The sheathing of the door should not be driven tight, in order to prevent warping as much as possible.

The closed door stop should be of wood 3¾ inches wide, secured by six ½-inch bolts. The bolts should be staggered to prevent splitting the wood. There should also be at least two metal closed door stops, each secured with two ½-inch bolts with furring under the sheathing.

The door stops for the open door position should be at least two in number and provided with lips. Each stop should be secured with not less than two ½-inch bolts, with furring under the sheathing, unless posts or girths are available.

There should be two 1-inch half-oval chafing strips to protect the sheathing back of the door when open; one strip located near the bottom and the other at about one-half the height of the door.

There should be at least four bottom guides, located so that not less than two guides will engage the door in any position. Each guide should be secured to the sill of the car by at least two ½-inch bolts. The bolts for the guide at rear corner of door in closed position should have the nuts riveted over or bolts locked in other suitable manner.

The door hasp staple should be secured with two ⅜-inch carriage bolts, with the nuts inside and a washer under the nuts. The frame should be counterbored for the thickness of the nuts. The door hasp fastener should be secured with not less than two ⅜-inch bolts, with the nuts inside, and it is recommended that the fastener have a flange that will lip over the back of the wooden door stop. The door hasp fastener is a specialty which is usually purchased from manufacturers, therefore no drawing has been made.

The use of door hangers of patented designs has become almost universal, therefore it does not seem desirable to attempt to show a design for them. Each door hanger should be secured with not less than three bolts at least ⅜-inch diameter with nuts outside.

The track for the door hangers should be of some standard structural steel shape at least 3-16 inch thick, which is readily procurable on the market. The track should serve the double purpose of a runway for the hangers and a weather proof and spark proof door hood. The track should also be arranged so that the door cannot drop off if the hangers are broken.

End doors are not generally used on box cars, therefore the end door and fixtures for them have been omitted.

Protective Coatings for Steel Cars.

Committee—G. E. Carson, chairman; T. Rumney, S. A. Cromwell.

The committee at this time has some few cars under test, as follows:

One car covered with a coating of crude petroleum oil;

One car painted with special black paint and covered with a coating of good fish oil;

One car painted with special black paint and covered with a coating of locomotive cylinder oil;

One car painted with common paint and covered with equal parts of raw linseed oil and pure glycerin;

One car painted wth common paint and covered with Cleanola;

One car painted with common paint and covered with well-rubbed-in commercial tallow.

All of the above cars were sprayed on the inside with crude petroleum oil.

Following are the recommendations as far as the committee has gone:

Suitable buildings should be provided for the painting of cars, so that the painting of the equipment would not necessarily be confined to certain seasons of the year.

In the preparation of the assembled parts of new cars, they should not be exposed to the weather or permitted to rust before their assemblage. In all cases where metal is placed against metal, either riveted or bolted, it should be free from flash or rust and covered with one or two coats of red lead, and the mixture be heavy enough to exclude moisture. But this precaution will avail little unless extra care is taken that all the steel parts fit evenly.

After cars are ready for the first coating, it is necessary that all flash and rust be removed. This should be done under rigid inspection. Unless the flash is removed it will invariably begin to fall off inside of a year and continue as long as any remains, regardless of the number of coats of paint applied. It is recommended that all flash and rust be removed by sand blast, where possible. Dry cleaning (which is not as satisfactory) is also recommended by using steel scratch brushes, sandstone, or any tools which will answer the purpose, being particular to remove all the dust with suitable brushes or dusters. After following either of these cleanings, the application of three coats of paint at twenty-four-hour intervals is suggested.

In the preparation of cars for repainting, cleaning by sand blast is recommended, but if this cannot be done, then use the dry-cleaning process, as previously mentioned. After the dry cleaning, two coats of standard paint should be applied at twenty-four-hour intervals.

After taking all these precautions to protect the outside of the car, under ordinary conditions it is necessary to repaint at the expiration of three years, and where conditions are unfavorable to the equipment it will be necessary to repaint oftener.

The committee cannot be too emphatic as to the necessity of taking the proper care of the exterior, and regrets not being able to give the interior equal care.

The best of paint should be used in order to prevent rust after painting, and by using paint which has the greatest wearing elasticity, the less liability there is for the penetration of moisture. Adhesion is just as important, and to have perfect adhesion, the paint should dry from the inside out, the same as good varnish.

Elasticity must also be considered, for where adhesion is perfect and no elasticity in the materials, we cannot hope for good results. For the reason that expansion and contraction of the plates must be provided for, the use of linseed oil or its equivalent is preferred.

The painting of the inside of steel cars has been thought by some to be beneficial, but the committee can see no lasting benefits in this, and do not recommend it, but is of the opinion that coating the interior of the cars about once every six months with black oil would act as a preservative.

Further than this the committee is not able to offer any recommendations, and asks to be continued for another year in order to determine the results of the tests which are being made.

Triple Valve Tests.

Committee—A. J. Cota, chairman; R. K. Reading, E. W. Pratt, F. H. Scheffer, D. C. Ross.

The committee reported that the new 100-car, 10-inch, brake-cylinder testing rack has been built and shipped to Purdue University at Lafayette, Indiana, and that the material is now stored awaiting the completion of a room that is being especially built for housing the test rack. This building will be completed about June 20.

Journals on Standard Axles.

The topical discussion on the question: "Should journals of standard axles when fillets are partially worn, be made longer in order to get in a full size fillet? If so, what should be the limit of the length of journals?" was opened by W. E. Fowler (Can. Pac.) as follows:

"There are very few iron axles put under modern freight cars. The axle of to-day is that made of open hearth steel, a material which does not give good service in carrying heavy loads, or in sustaining severe shocks if its outline be disposed into sharp corners or angles, and the designers of the M. C. B. standard axles accordingly have provided, that, where there is a step or change of diameter, there should be a fillet or curved graduated connection between the larger and smaller diameters, since if a sharp corner or right angle be allowed, a fracture is invited at that point, and a great loss of property will probably ensue.

"The lengthening of journals of axles in order to replace worn fillets is a practice which is more or less followed on all railroads, but so far as my knowledge extends, there are no generally observed limits to this extension of length. In my opinion an axle with the journal fillet entirely worn out should, when withdrawn for changing wheels, be scraped. The reformation of the entire fillet with the consequent lengthening of the journal, is an unsafe practice, as when the fillet is quite worn out there is, in all probability, an incipient crack where the fillet formerly was, and it is only inviting trouble to return such axles to service.

"Considering the disastrous results that follow a broken journal, I think "an ounce of prevention is worth a pound of cure" in this as in many other cases, and the prevention consists in scrapping all axles with worn out fillets.

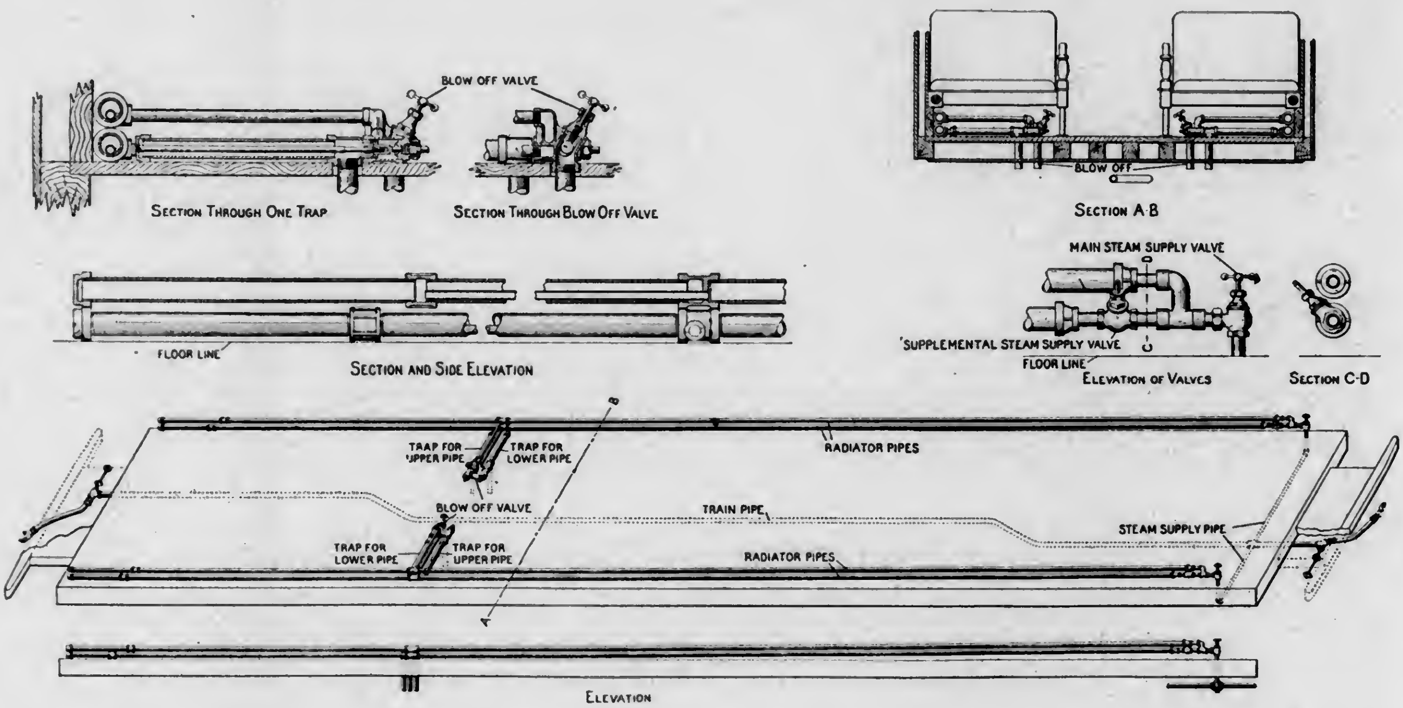
"There are, however, many axles drawn from service on account of wheel failures that have fillets partially worn, and which may in the opinion of many be made fit for long further service by putting them in the lathe and lengthening back the dust guard shoulder and so renew the fillet, so essential to the load carrying ability of the journal.

"I think it will be agreed generally that excessive lateral movement of the journal bearing on the journal (which, of course, means also movement of the superimposed load) is not desirable, in fact, that it is injurious to wheels, axle, and truck, car body and track, and in view of the heavy loads now carried, the speed attained and the consequent stresses on the wheel flange, we should make our wear limits less and our inspection more rigid, to preserve the same factor of safety with the heavy capacity car and the high speed that we formerly had with the light car and low speed.

"We have limits of diameter for journals, wheel seats and axle centers, we have limits for thickness of collars, and we should have limits for length of standard journals, for the reasons enumerated, as also to keep within reasonable limits the lateral movement of journal bearings (and consequently the truck frame) on the journals.

"In view of my opinion that only partially worn fillets should be reformed by lengthening the journal, I think that a length limit of 7½ inches should be set for 7-inch journals, 8½ inches for 8-inch journals, and 9½ inches for 9-inch journals, and 10½ inches for 10-inch journals."

Mr. Hennessey agreed with Mr. Fowler and on a motion by Mr. Forsyth the subject was referred to the committee on standards.



REGULATING DIRECT STEAM HEATING SYSTEM

The Safety Car Heating & Lighting Company has developed a regulating system of direct steam heating to meet the desire of railroads for a steam heating system which is capable of easy adjustment to meet the varying conditions of outside temperature. The most practicable method of accomplishing this result is by so arranging the system that the amount of radiating pipe in service may be varied at will. It is not possible to secure the best results by maintaining a constant radiating surface and varying the steam pressure, as there is not sufficient difference in its tendency to heat the surrounding air between a pipe containing steam at say 45 pounds (290 degrees Fahr.) and one at 2 pounds pressure (218 degrees Fahr.). This allows a possible reduction in temperature of the radiating pipes of 72 degrees, or but 25 per cent. Neither can this result be accomplished by maintaining steam in the radiators at atmospheric pressure, as it is then neither possible to increase nor diminish the temperature of the radiators, and no control whatever is had of the amount of heat delivered to the car.

In this new arrangement there are a total of four radiating pipes running the length of the car, two being located on each side, and each pipe being supplied with independent admission valve and automatic trap for taking care of the water of condensation. It is thus possible to use either one, two, three or four pipes, at a time; or, considering four pipes as the maximum, to reduce the heating effect either 25, 50, or 75 per cent., as may be desired.

The live steam is taken from the train pipe by means of a cross, and passes through a 1" pipe to admission valves located on opposite sides of the car. When both these valves and supplementary valves in the lower radiating pipe are opened wide, steam will enter both the upper and lower pipes of the system, and the maximum heating effect will be obtained. The supplementary valve, which controls the lower pipe, is arranged to be operated by a key or wrench, the object being to keep this valve closed the greater part of the time, thus avoiding overheating the car. This will also very materially assist in preventing the rear cars from being robbed of steam when first heating up long trains. In very cold weather, however, if more radiating surface is desired, this valve is opened on either one or both sides of the car.

It will be readily appreciated that the use of this system will not only result in a substantial saving in steam consumption while the car is in actual service, but will also considerably reduce the cost of keeping cars warm at terminals and yards, as ordinarily a car which is not moving and whose doors, windows and ventilators are closed may be kept sufficiently warmed by the use of but one of the four radiating pipes, with a consequent saving in the amount of steam consumed.

Construction.

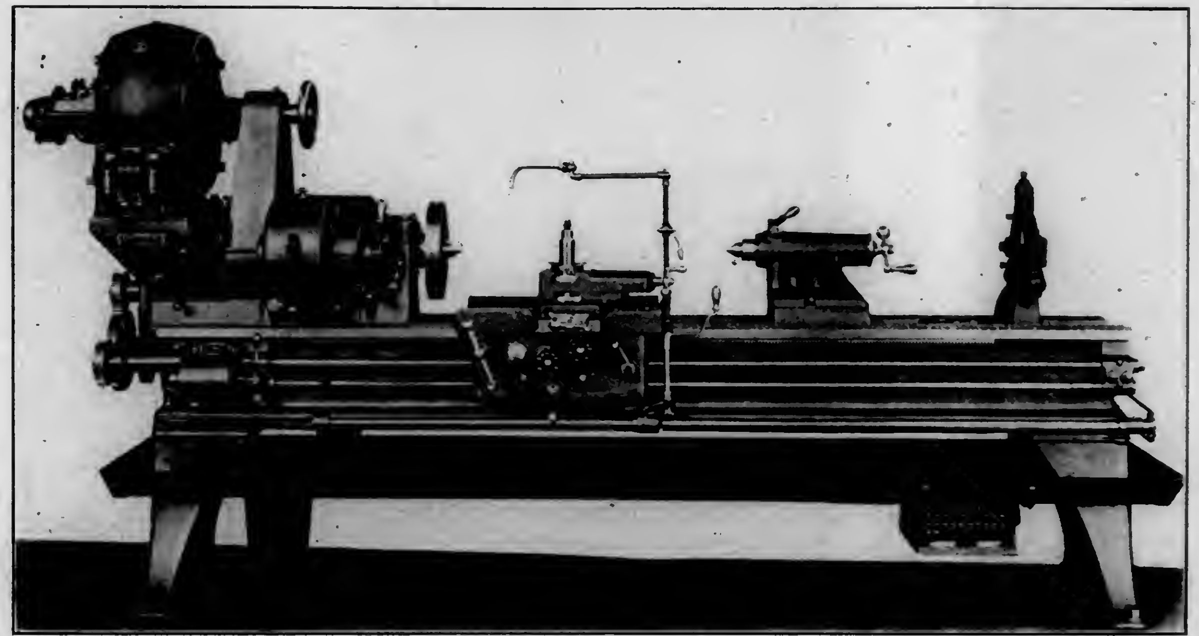
At a point about two-thirds the length of the car from the steam inlet, a special 2" x 1" eccentric tee is located in each radiating pipe. This tee is cast with a vertical web or wall in which are two openings, one tapped with ¾" pipe thread and the other being a small hole for the purpose of facilitating drainage. A ¾" pipe which is screwed into the larger opening lays along the bottom of the 2" radiating pipe and extends to a coupling located a few feet from the end of the 2" pipe. One-inch pipes connect these special tees with fitting, in which are incorporated a blow-off valve and two horizontal traps, and constructed in such a manner that each of the 1" pipes is independently connected through a separate passage with its corresponding trap. The blow-off valve is so arranged that it may be used to operate both the upper and lower pipes. Into the outlet of each trap and of the blow-off valve is screwed a 1½" drain pipe, passing down through the car floor.

In order to understand the operation of this system, suppose all valves to be closed. Now, if either of the main admission valves be opened, steam will enter and pass along the upper 2" radiating pipe on one side of the car until it reaches the special tee. It will then pass through the ¾" pipe (which is introduced to prevent air being pocketed in the dead end of the radiator), expand and fill the remainder of the 2" pipe, and pass through the 1" connection to the inlet of one of the automatic traps. This trap consists of a brass pipe extending horizontally nearly to the radiator and containing a small iron rod permanently attached to one end of the brass pipe, the other end being free to slide and carrying an adjustable disc which seats against the end of the brass pipe. When the car is first put into service, this trap is opened wide and steam allowed to blow through it until it is thoroughly hot. It is then closed by turning up the projecting stem with a key or wrench and permanently securing it by means of a locknut. Thereafter the trap will require no further adjustment, as, on account of the difference in contraction or expansion between the iron rod carrying the valve disc and its surrounding brass pipe, the valve will tend to open when the trap cools, or close when it becomes warmer, thus automatically allowing the water of condensation but no steam, to pass out through the drain pipe.

It will be noted that the traps are adjusted and the entire system operated from within the car, making it unnecessary to get under the car for any purpose.

The operation of each of the other three radiating pipes is, of course, identical with that of the one referred to, and any of the radiators may be turned on or off at will without the necessity of touching the traps or blow-off valves in any way.

On account of the traps being wholly within the car, it is practically impossible for them to freeze; but even should either of them become frozen after steam has been cut off from the car, it could still be readily thawed out by simply turning steam on the remaining pipes.



SPRINGFIELD RAPID REDUCTION LATHE.

HIGH POWER RAPID REDUCTION LATHE.

A recent design of the No. 3, 19-inch, high power, rapid reduction lathe, motor driven, made by the Springfield Machine Tool Company, Springfield, O., is shown in the illustration above. To obviate the heavy and cumbersome construction which would be necessary to make the proper reduction, between the motor and spindle speeds, through gearing, a silent chain is used. The motor shown is of the variable speed type—500 to 1,000 r. p. m. —and has a capacity of 7½ h.p.

The higher spindle speeds are obtained by driving the spindle direct from the motor. The intermediate speeds are obtained through a train of gears consisting of one set of spur and one set of spiral gears. The use of spiral gears makes it possible to turn out work with a very fine finish. The slow speeds are obtained through a double set of back gears. The mechanical speed changes are made by positive steel clutches so arranged that the machine does not have to come to a dead stop before the changes can be made. The motor driven lathe provides for a variation of spindle speed ranging from 10 to 285 r. p. m. The same lathe, belt driven, has ten mechanical changes of speed, and with a two-speed countershaft is designed to give a cutting speed of 80 ft. per minute for diameters from 1½ to 18½ in. The motor controller is placed at the rear of the bed and is operated by the handle shown to the right of the carriage.

The head is heavily ribbed and tied together at all points where it is liable to heavy strains. The spindle is extra heavy and runs in large journals of lumen bearing metal. The spindle and back shaft journals are oiled by babbit rings of triangular shape, which furnish a plentiful supply of oil. The tail stock is very rigid and heavy. The carriage is of a new design, being heavier and having larger bearing surfaces than generally used, adapting it for the heavy duty for which the lathe has been designed. The compound rest is also of a new design and is clamped by bolts on either side. Both the cross feed screw and the compound rest screw have micrometer collars. The friction knobs for throwing in and out the gears and the longitudinal feeds are made with a series of small beads on the circumference, thus allowing the operator to get a better grip on them. The rack pinion is so made that it may be withdrawn at any time when chasing threads.

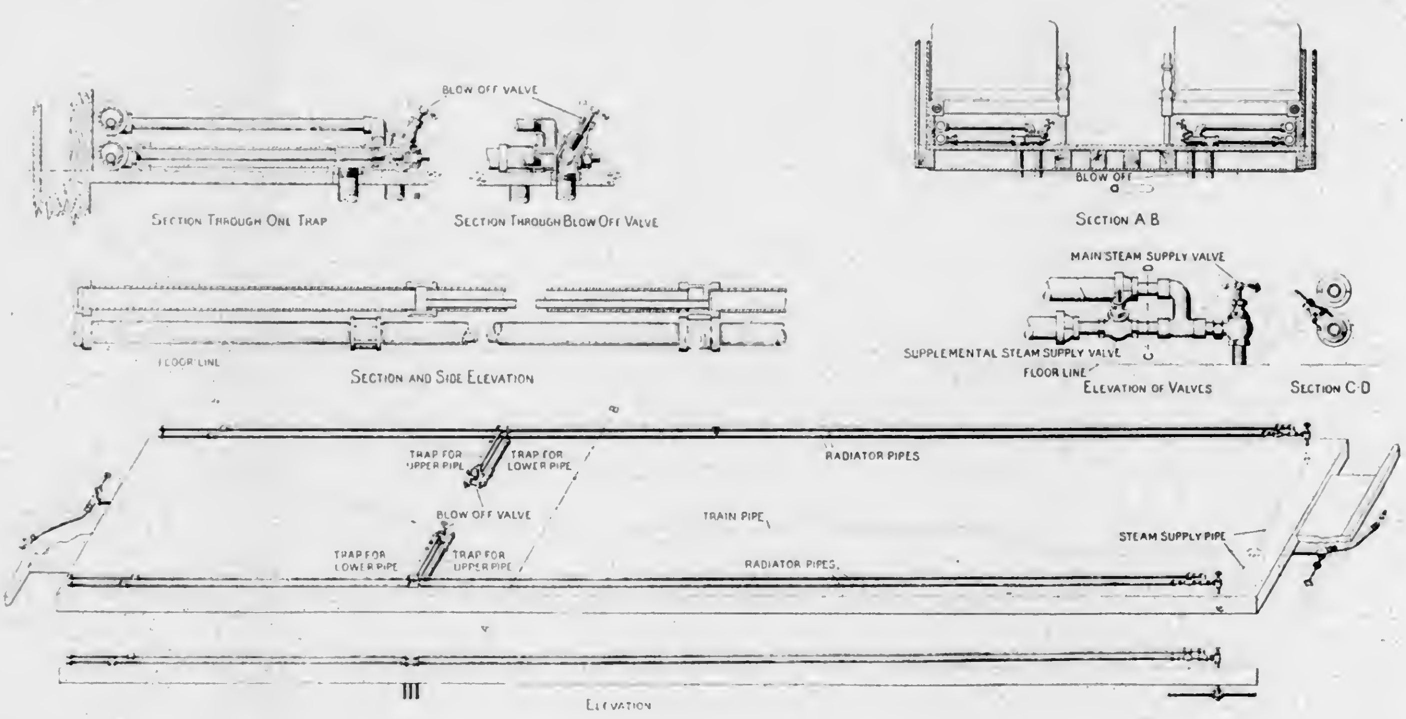
The machine illustrated is equipped with a modification of the rapid change system generally used, and also with a rapid feed changing box, which furnishes six feeds in geometrical progression. If desired the lathe may be equipped with the well-known Ideal rapid change gears. Whichever arrangement is used an automatic stop and reverse is arranged for, it being possible to control the reverse from either the head or the apron. Tests have been made on 60 point carbon steel with a feed of 5/32 in., a reduction in diameter of 1½ in., and a cutting speed of 60 ft. per minute. One of these lathes was on exhibition at the Atlantic City conventions in June.

SUCCESS CHEMICAL FIRE EXTINGUISHER.

The H. W. Johns-Manville Company, 100 William street, New York, has recently brought out a new portable fire extinguisher. This extinguisher is unusually strong and heavy and is made of non-corrosive materials throughout. The body is of extra heavy cold rolled copper securely riveted and reinforced and is tested to a pressure of 350 lbs. or four times the required strength. The hose, which is tested to 400 lbs. to the square inch, is joined to the body by a swivel ground joint and cannot be pulled off, being detachable only by means of a wrench.

The extinguisher is put into action by simply being turned bottom side up and the resultant mixture of the sulphuric acid in the bottle secured in a brass cage on the interior, with the three gallons of water charged with bicarbonate of soda, develops instantly a pressure sufficient to send a chemical stream a distance of 50 ft. The flow of the sulphuric acid is automatically regulated so that the correct amount of gas is generated at all times and explosion is impossible. The chemical stream from this extinguisher acts as a blanket and smothers the fire; the acid, however, is all neutralized before it leaves the machine and the stream will not injure the material with which it comes in contact. This extinguisher is approved by the National Board of Fire Underwriters.

Convention of Railroad Master Blacksmiths' Association. —The sixteenth annual convention of the International Railroad Master Blacksmiths' Association will be held at the Grand Hotel, Cincinnati, O., August 18, 19 and 20. At this convention



REGULATING DIRECT STEAM HEATING SYSTEM

The Safety Car Heating & Lighting Company has developed a regulating system of direct steam heating to meet the desire of railroads for a steam heating system which is capable of easy adjustment to meet the varying conditions of outside temperature. The most practicable method of accomplishing this result is by so arranging the system that the amount of radiating pipe in service may be varied at will. It is not possible to secure the best results by maintaining a constant radiating surface and varying the steam pressure, as there is not sufficient difference in its tendency to heat the surrounding air between a pipe containing steam at say 45 pounds (290 degrees Fahr.) and one at 2 pounds pressure (218 degrees Fahr.). This allows a possible reduction in temperature of the radiating pipes of 72 degrees, or but 25 per cent. Neither can this result be accomplished by maintaining steam in the radiators at atmospheric pressure, as it is then neither possible to increase nor diminish the temperature of the radiators, and no control whatever is had of the amount of heat delivered to the car.

In this new arrangement there are a total of four radiating pipes running the length of the car, two being located on each side, and each pipe being supplied with independent admission valve and automatic trap for taking care of the water of condensation. It is thus possible to use either one, two, three or four pipes, at a time; or, considering four pipes as the maximum, to reduce the heating effect either 25, 50, or 75 per cent., as may be desired.

The live steam is taken from the train pipe by means of a cross, and passes through a 1" pipe to admission valves located on opposite sides of the car. When both these valves and supplementary valves in the lower radiating pipe are opened wide, steam will enter both the upper and lower pipes of the system, and the maximum heating effect will be obtained. The supplementary valve, which controls the lower pipe, is arranged to be operated by a key or wrench, the object being to keep this valve closed the greater part of the time, thus avoiding overheating the car. This will also very materially assist in preventing the rear cars from being robbed of steam when first heating up long trains. In very cold weather, however, if more radiating surface is desired, this valve is opened on either one or both sides of the car.

It will be readily appreciated that the use of this system will not only result in a substantial saving in steam consumption while the car is in actual service, but will also considerably reduce the cost of keeping cars warm at terminals and yards, as ordinarily a car which is not moving and whose doors, windows and ventilators are closed may be kept sufficiently warmed by the use of but one of the four radiating pipes, with a consequent saving in the amount of steam consumed.

Construction.

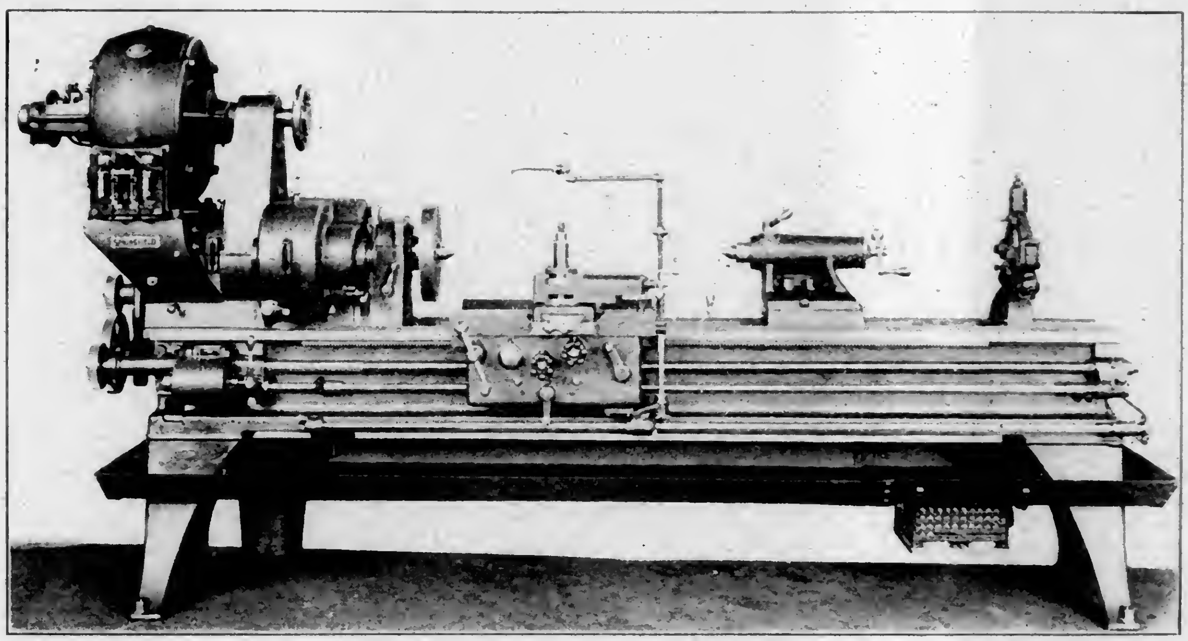
At a point about two-thirds the length of the car from the steam inlet, a special 2" x 1" eccentric tee is located in each radiating pipe. This tee is cast with a vertical web or wall in which are two openings, one tapped with ¾" pipe thread and the other being a small hole for the purpose of facilitating drainage. A ¾" pipe which is screwed into the larger opening lays along the bottom of the 2" radiating pipe and extends to a coupling located a few feet from the end of the 2" pipe. One inch pipes connect these special tees with fitting, in which are incorporated a blow off valve and two horizontal traps, and constructed in such a manner that each of the 1" pipes is independently connected through a separate passage with its corresponding trap. The blow off valve is so arranged that it may be used to operate both the upper and lower pipes. Into the outlet of each trap and of the blow off valve is screwed a 1½" drain pipe, passing down through the car floor.

In order to understand the operation of this system, suppose all valves to be closed. Now, if either of the main admission valves be opened, steam will enter and pass along the upper 2" radiating pipe on one side of the car until it reaches the special tee. It will then pass through the ¾" pipe (which is introduced to prevent air being pocketed in the dead end of the radiator), expand and fill the remainder of the 2" pipe, and pass through the 1" connection to the inlet of one of the automatic traps. This trap consists of a brass pipe extending horizontally nearly to the radiator and containing a small iron rod permanently attached to one end of the brass pipe, the other end being free to slide and carrying an adjustable disc which seats against the end of the brass pipe. When the car is first put into service, this trap is opened wide and steam allowed to blow through it until it is thoroughly hot. It is then closed by turning up the projecting stem with a key or wrench and permanently securing it by means of a locknut. Thereafter the trap will require no further adjustment, as, on account of the difference in contraction or expansion between the iron rod carrying the valve disc and its surrounding brass pipe, the valve will tend to open when the trap cools, or close when it becomes warmer, thus automatically allowing the water of condensation but no steam, to pass out through the drain pipe.

It will be noted that the traps are adjusted and the entire system operated from within the car, making it unnecessary to get under the car for any purpose.

The operation of each of the other three radiating pipes is, of course, identical with that of the one referred to, and any of the radiators may be turned on or off at will without the necessity of touching the traps or blow-off valves in any way.

On account of the traps being wholly within the car, it is practically impossible for them to freeze; but even should either of them become frozen after steam has been cut off from the car, it could still be readily thawed out by simply turning steam on the remaining pipes.



SPRINGFIELD RAPID REDUCTION LATHE.

HIGH POWER RAPID REDUCTION LATHE.

A recent design of the No. 3, 19 inch, high power, rapid reduction lathe, motor driven, made by the Springfield Machine Tool Company, Springfield, O., is shown in the illustration above. To obviate the heavy and cumbersome construction which would be necessary to make the proper reduction, between the motor and spindle speeds, through gearing, a silent chain is used. The motor shown is of the variable speed type—500 to 1,000 r. p. m. and has a capacity of 7½ h.p.

The higher spindle speeds are obtained by driving the spindle direct from the motor. The intermediate speeds are obtained through a train of gears consisting of one set of spur and one set of spiral gears. The use of spiral gears makes it possible to turn out work with a very fine finish. The slow speeds are obtained through a double set of back gears. The mechanical speed changes are made by positive steel clutches so arranged that the machine does not have to come to a dead stop before the changes can be made. The motor driven lathe provides for a variation of spindle speed ranging from 10 to 285 r. p. m. The same lathe, belt driven, has ten mechanical changes of speed, and with a two-speed countershaft is designed to give a cutting speed of 80 ft. per minute for diameters from 1½ to 18½ in. The motor controller is placed at the rear of the bed and is operated by the handle shown to the right of the carriage.

The head is heavily ribbed and tied together at all points where it is liable to heavy strains. The spindle is extra heavy and runs in large journals of hunen bearing metal. The spindle and back shaft journals are oiled by babbit rings of triangular shape, which furnish a plentiful supply of oil. The tail stock is very rigid and heavy. The carriage is of a new design, being heavier and having larger bearing surfaces than generally used, adapting it for the heavy duty for which the lathe has been designed. The compound rest is also of a new design and is clamped by bolts on either side. Both the cross feed screw and the compound rest screw have micrometer collars. The friction knobs for throwing in and out the gears and the longitudinal feeds are made with a series of small beads on the circumference, thus allowing the operator to get a better grip on them. The rack pinion is so made that it may be withdrawn at any time when chasing threads.

The machine illustrated is equipped with a modification of the rapid change system generally used, and also with a rapid feed changing box, which furnishes six feeds in geometrical progression. If desired the lathe may be equipped with the well-known Ideal rapid change gears. Whichever arrangement is used an automatic stop and reverse is arranged for, it being possible to control the reverse from either the head or the apron. Tests have been made on 60-point carbon steel with a feed of 5/32 in., a reduction in diameter of 1½ in., and a cutting speed of 60 ft. per minute. One of these lathes was on exhibition at the Atlantic City conventions in June.

SUCCESS CHEMICAL FIRE EXTINGUISHER.

The H. W. Johns-Manville Company, 100 William street, New York, has recently brought out a new portable fire extinguisher. This extinguisher is unusually strong and heavy and is made of non-corrosive materials throughout. The body is of extra heavy cold rolled copper securely riveted and reinforced and is tested to a pressure of 350 lbs. or four times the required strength. The hose, which is tested to 300 lbs. to the square inch, is joined to the body by a swivel ground joint and cannot be pulled off, being detachable only by means of a wrench.

The extinguisher is put into action by simply being turned bottom side up and the resultant mixture of the sulphuric acid in the bottle secured in a brass cage on the interior, with the three gallons of water charged with bicarbonate of soda, develops instantly a pressure sufficient to send a chemical stream a distance of 50 ft. The flow of the sulphuric acid is automatically regulated so that the correct amount of gas is generated at all times and explosion is impossible. The chemical stream from this extinguisher acts as a blanket and smothers the fire; the acid, however, is all neutralized before it leaves the machine and the stream will not injure the material with which it comes in contact. This extinguisher is approved by the National Board of Fire Underwriters.

CONVENTION OF RAILROAD MASTER BLACKSMITHS' ASSOCIATION.—The sixteenth annual convention of the International Railroad Master Blacksmiths' Association will be held at the Grand Hotel, Cincinnati, O., August 18, 19 and 20. At this convention

papers on the following subjects will be presented: Flue Welding, George Lindsay, chairman; Tools and Formers for Bulldozers and Steam Hammers, H. M. Stewart, chairman; Case Hardening, W. V. Laizure, chairman; High Speed Steel and the Results Obtained, J. S. Sullivan, chairman; Piece Work, T. J. McCann, chairman; Frogs and Crossings, T. F. Keane, chairman; Locomotive Frame Making and Repairs, J. T. McSweeney, chairman, and Thermit Welding, G. W. Kelley, chairman. Mr. A. L. Woodworth, Lima, O., is secretary and treasurer of this association.

BOOK NOTES.

Locomotive Engine Running and Management. By Angus Sinclair. Twenty-second edition. Revised and enlarged. 430 pages. Cloth. Illustrated. Published by John Wiley & Sons, 43 E. 19th street, New York. Price, $2.00.

This book needs no description to the older enginemen and to the younger men it will suffice to say that its title conveys the best idea of the work and is accurate in every sense of the word. If more is needed it is given in the sub-title, which states that the book explains how to manage locomotives in running different kinds of trains with economy and dispatch; gives plain descriptions of valve gears, injectors, brakes, lubricators and other locomotive attachments; treats on the economical use of fuel and steam and presents valuable directions about the care, management and repairs of locomotives and their connections.

Locomotives a Vapeur. By Joseph Nadal. Bound in cloth; 4½ x 7 in.; 300 pages; illustrated. Published by the Encyclopedie Scientifique, 8 Place de L'Odéon, Paris, France. Price, $1.00.

This book deals in detail with the design and construction of modern French locomotives, being fully illustrated with examples of the latest and best practice in that country. It is written in French.

CATALOGS

IN WRITING FOR THESE PLEASE MENTION THIS JOURNAL.

Inter-Pole Motors.—The Electro-Dynamic Co., Bayonne, N. J., is issuing circulars Nos. 32 and 33, both being on the subject of the inter-pole variable speed motors for driving machine tools, etc. These circulars contain some very interesting information.

The Foundrymen's Reference Book.—The Whiting Foundry Equipment Company, Harvey, Ill., is issuing a booklet which, in addition to many of its well known devices, also contains a few arrangements for reducing operating costs in foundries that are absolutely new. This company furnishes everything that is needed in the modern foundry.

Gisholt Methods in Railroad Shops.—The Gisholt Machine Company, Madison, Wis., is issuing a pamphlet describing and illustrating the Gisholt lathes as applied to railroad uses; also various Gisholt tools. These include illustrations showing the machine and the work which it is capable of doing. Most of the catalog is given up to the work within the capacity of the Gisholt lathe which was illustrated and described on page 24 of the June issue of this journal.

Railway Converter Sub-Stations.—The General Electric Company, Schenectady, N. Y., has just issued a very comprehensive bulletin (No. 4593), devoted to the above subject. This publication gives a general description of the various pieces of sub-station apparatus, including rotary converters, transformers, reactances, blowers, cables, switch-boards, etc., and includes illustrations of converter stations operated by various well-known railway companies. It contains also plans and elevations showing different arrangements of sub-station apparatus. Bulletin No. 4590, on the subject of self-starting devices for alternating current motors, is also being issued.

Lathes, Valve-Milling Machines and Oil Separators.—The American Tool and Machine Company, 109 Beach street, Boston, Mass., is issuing an illustrated catalog showing a number of new and very interesting designs of the above machines. The catalog is given up principally to turret lathes, which are shown in a variety of sizes and with a number of new attachments. Several machines for separating oil from chips, turnings or cuttings of any kind are also included.

Grinding Points Ground Down.—The Norton Co., Worcester, Mass., is issuing a little booklet which contains a large number of most valuable hints and helps for all those who have grinding to do. This covers very fully the subject of the selection of a wheel, the mounting and truing, the speed and general suggestions on grinding. These helps are the result of a long and very intimate experience of this company in this field and are of the greatest value.

Electric Generators.—Among the bulletins recently issued by the Crocker-Wheeler Company, Ampere, N. J., are No. 103 which fully illustrates and thoroughly describes the hydroelectric development on the Chicago Drainage Canal, which at present has a capacity of 16,000 h. p. and will ultimately deliver 36,000 h. p. Bulletin No. 104 describes the type of direct current railway generators now being built by this company and shows illustrations of a number of recent installations.

Mallet Articulated Compound Locomotives.—The Baldwin Locomotive Works, Philadelphia, Pa., is issuing Record No. 65, which consists largely of a very comprehensive and complete paper read by Mr. Greenough before the Engineers' Club of Philadelphia, March, 1908, on the Mallet Articulated Compound Locomotive. The Record also includes illustrations and complete dimensions of a number of designs of this type of locomotive which have been built by this company. Line drawings showing some of the more important details of several of these designs are also included.

Sweating Pipes.—Damage is often caused during hot weather by the collection of moisture on water pipes to an extent which causes it to drip and damage merchandise, carpets, etc. The H. W. Johns-Manville Company, 100 William street, New York, is issuing a leaflet describing its anti-sweat pipe covering, which is a sure preventive of this difficulty and is very reasonable in price. The same company is also issuing a leaflet descriptive of its compound called "Ferro-Cement," which is used for smoothing over and filling in blow holes in iron and steel castings.

Bolt and Pipe Threading, and Nut Tapping Machinery.—The Foote-Burt Company of Cleveland has issued a catalog describing the Reliance bolt threading, pipe threading and nut tapping machinery and accessories made by it. The catalog opens with a detailed description of the Reliance die head and its operation. Other details of the bolt cutters are then considered, after which specifications and illustrations are presented for the different sizes and types of these machines. The application of the motor drive is also considered. Information is presented concerning adjustable tap chucks, short hob or master taps and machine or nut taps. A short section describes the making and recutting of dies and this is followed by a number of reference tables, including information concerning standard screw threads; decimal equivalents of parts of an inch; millimeters in inches; table of surface speeds, including the speeds recommended for cutting bolts and tapping nuts; length of threads cut on bolts; English and Whitworth standard pipe threads; standard dimensions of wrought iron welded pipe; lap welded well casing and a table of areas, weights per lineal inch and weights per lineal foot of round bolt iron.

NOTES

Willis C. Squire.—Mr. Squire announces that he has opened an office as manufacturers agent at 209 Western Union Building, Chicago. He will handle railway supplies and specialties, gasoline locomotives, turntables, cranes, signaling devices, track materials, etc.

Crocker-Wheeler Company.—The following officers of the above company were elected on July 10th: President, S. S. Wheeler; Vice-President and Chief Engineer, Gano Dunn; Second Vice-President, A. L. Doremus; Secretary, Rodman Gilder; Treasurer, W. L. Brownell; Assistant Secretary, J. B. Milliken, and Assistant Treasurer, G. W. Bower.

Dearborn Drug and Chemical Works.—At a recent meeting of the Board of Directors of this company. W. A. Converse was elected to the position of secretary and chemical director, and Ralph Browning was elected to the office of treasurer. Both of these gentlemen have been connected with the company for several years.

Pressed Steel Car Company.—At the Atlantic City conventions the Pressed Steel Car Company exhibited one of the order of 85 steel passenger coaches which it is now delivering to the Pennsylvania Railroad. These cars are unusually interesting in design and attractive in appearance. They were fully illustrated and described on page 232 of the June, 1907, issue of this journal.

Sale of the Schoen Steel Wheel Plant.—The Carnegie Steel Co., Pittsburgh Pa., has bought the property of the Schoen Steel Wheel Co., Philadelphia, Pa., whose plant is at McKees Rocks, Pa. Charles T. Schoen, who established the plant and was its sole owner, has retired from active work, but he will, however, continue with the steel corporation in an advisory capacity as regards the wheel plant. The transfer involves the plant at McKees Rocks, which has been running about three years and has a capacity of 800 wheels a day, some 21 acres of ground adjoining the plant of the Pressed Steel Car Co., of Pittsburgh, Pa., and a steel plant about half completed. Some time ago Mr. Schoen decided to erect a steel plant to furnish the steel needed in the wheel plant. Whether this will be completed or dismantled is not yet decided.

A PRACTICAL DRAWING OFFICE SYSTEM

CANADIAN PACIFIC RAILWAY.

BY G. I. EVANS, CHIEF DRAUGHTSMAN.

PART II.

SYNOPSIS.

Maintenance Regulations.—Maintenance regulations describing the manner in which certain recurrent duties are to be performed, such as washing and testing boilers; testing staybolts, gauges, etc.; inspection of wheels; limits of wear of tires, axles, piston rods and a variety of subjects which are not convenient to issue by means of blue prints, are issued on what are known as "Maintenance Regulation Cards," samples of which are shown in Figs. 14 and 15.

These are printed by the 8 x 11 in. press on heavy 5 x 8 in. cards, the same group classification being used as for tracings. The designating letters have, however, been changed to "M. R.," which indicate a "Maintenance Regulation." The office record of these cards is kept by an index, similar to that used for tracings. Revisions or additions to any of the cards in use are made by a re-issue, all cards out on the road being called in, corrected and again sent out under a new issue number, which is printed on them together with the date of revision.

Maintenance regulations are issued to all motive power and other officials having charge of the work described on them, and, when kept in ordinary card file trays, arranged by group, form a very convenient reference.

Changes and Revisions.—It becomes necessary from time to time, to make certain changes in the details of equipment, either along the lines of improved appliances or strengthening parts which have proven weak. A great amount of this work can be very successfully handled at the various division shops and roundhouses, but to do so it is essential that some system be adopted of notifying the officials concerned and giving them full instructions as to how and when the work is to be done, also the reasons for so doing.

These conditions can be met best by issuing blue prints showing the changes to be made, accompanied by a manifest which will give all additional particulars as to the performance of the work. Such a system has been worked out by the revision notice column located on the card at the upper right-hand corner of every tracing (Fig. 7), used in conjunction with a manifest form as shown in Fig. 16.

The exact method employed is first to make the necessary changes to the tracing; a record covering the revision is entered in the column provided for that purpose, as shown in Fig. 7. The manifest is now numbered and written up, one being addressed to each person who receives a print of the revised tracing, the number and title of which is written in the columns headed respectively "Drawing Number" and "Subject"; in the "Remarks" column is a short description of the change and reason for it, so as to give the recipient a clear understanding of the work, while in the column headed "Application" the time at which it is to be done, such as "Immediately," "First shopping," etc., is filled in. On receipt of the manifest and prints the receipt form is signed and returned to the drawing office, where it is filed.

63 M R 1.

CANADIAN PACIFIC RAILWAY. LINES WEST OF FORT WILLIAM. MOTIVE POWER DEPARTMENT.	MAINTENANCE REGULATION 63 M R 1. TESTING & CARE OF STEAM & AIR GAUGES. ISSUE NO 1 AUGUST 1, 1906.

1. Each divisional shop must be equipped with standard testing apparatus and each head-quarter station with standard test gauge.
2. Test gauges must be sent in every three months for comparison on standard testing apparatus, being replaced by a tested gauge.
3. Steam, steam heat and air gauges on all locomotives in service to be tested by comparison with standard test gauge when engine undergoes staybolt test.
4. Gauges on all stationery boilers to be tested by comparison with standard test gauge at intervals not exceeding twelve months
5. At stations, other than head-quarter stations gauges will be attended to when necessary, by a man sent for that purpose or by sending them to the nearest head-quarters station.
6. All tests as above will be reported on form M P.3 every three months to Division Master Mechanic who will sign same and forward it to the Asst. Supt. Motive Power Winnipeg, retaining a copy for his own records.

FIG. 14.—ONE OF THE "MAINTENANCE REGULATION" CARDS.

Distribution of Blue Prints, Etc.—These manifest forms may also be used for the issue of prints for record purposes, pattern catalog and manufactured material lists, etc. The issue symbols, previously mentioned in this article, are used for both the ordinary issue of prints to Angus Shops for new work, and manifest issues, such as have just been described, a space also being reserved on the manifest form for their insertion. These symbols are shown at the top of the following page.

The object of these issue symbols is this: When a new trac-

A Angus Shops .... { 1 Print for Supt. of Shops.
                            1 " on sheet iron for Machine Shop.
B " " .... 1 " " " " " " Boiler Shop.
C " " .... 1 " " " " " " Blacksmith Shop.
D " " .... 1 " " " " " " Switch Shop.

G { 1 Print, 1 " on sheet iron } — Divisional Main Shops. McAdam Junction. Carleton Junction. Toronto Junction. North Bay.

R 1 Print for Main Roundhouse
S 1 Print on sheet iron for Main Roundhouse
— McAdam Junction. Vanceboro. Brownville. Megantic. Farnham. Montreal (Glen Yard). Hochelaga. Outremont. Carleton Junction. Chalk River. Havelock. Toronto (Union Station). Toronto Junction. London. Windsor. North Bay. Cartier. Chapleau. White River. Schreiber. Webbwood.

V—Drawing Office File,
X—New engine file,
Z—General file.

SYMBOLS USED IN CONNECTION WITH THE DISTRIBUTION OF BLUE PRINTS.

ing is made the shops or individuals requiring copies are determined upon, and the letter or letters representing these issues are entered in the proper column on the tracing; all persons having anything to do with the subsequent handling know exactly what prints are to be supplied and to whom they are to be delivered; itemizing, the procedure is as follows: In the case of a manifest issue the official dictating the manifest determines who shall receive copies and the stenographer writing it knows from the symbols mentioned, how many sheets to write and to whom to address them; the symbols, in the meantime are noted on the tracing which is sent to the printing office and the foreman there knows without further instruction how many prints to make and how many to mount on sheet iron.

Suppose that the above issue was to "G. R.," which indicates one reference print and one mounted on sheet iron for each division main shop and one reference print for each division roundhouse, all of which would, naturally, be sent to the official in charge of that division for distribution to his subordinates. He, having the dispatch symbols before him both on his manifest and print, will know at once for whom the other prints are intended.

In the case of a new tracing which is to be issued to Angus Shops on a locomotive building order, a manifest is of course unnecessary, full instructions being on the drawing. The issue symbols in this case, for a forged locomotive detail requiring machining, would be A, C, X, indicating one print for the shop superintendent's reference file, one each mounted on sheet iron for the machine and blacksmith shops and one to be bound in the drawing office record book for the locomotive represented. The tracing bearing these symbols is sent to the printing office, the proper number of prints is made and three of them are sent to the shop superintendent, his clerk knowing at once how to dispose of them without further instructions.

Such a system, in proper operation, works with mechanical precision, the progress of the prints from the time the tracing is approved being a series of predefined movements through the various departments, unnecessary handling and wrong delivery being eliminated by the simple addition of two or three letters on the tracing.

Changes in Progress.—One of the most serious and difficult problems which the average motive power drawing office is up against, is that of keeping the drawings and information lists which it has distributed through the various departments and shops, and which must still be regarded as part of the drawing office record, in a correct and up-to-date condition, so that they may be relied upon to tell accurately what is on any locomotive, car or other equipment. To illustrate this, suppose that a certain class of locomotive, of which there are fifteen, is to be rebuilt and a large number of the old parts replaced by new ones of an entirely new design. All these locomotives cannot be withdrawn from service immediately, and even if they could, no railroad shop has the facilities for doing all of the work at once. The work will extend over a period of from six months upwards and there will be two sets of records, one representing a gradually increasing number of locomotives of this class and the other a decreasing number. In the meantime both old and rebuilt locomotives will be in service, light repairs will be made on the old locomotives to keep them running until their turn comes to be rebuilt, the rebuilt locomotives will also be kept in repair, and new parts will be required from time to time for each.

Again, suppose a certain class of locomotive is to be equipped with a complete set of new side rods, which will take an entirely different design of bearing, and that orders have been issued to make the change only when the old rods show signs of failure: under these conditions it may be a matter of years before the last locomotive is changed, and in the meantime the bearings through natural wear will have to be renewed occasionally.

It will be evident from the two preceding examples that a railroad making use of a system of distributing information, such as the "Pattern" and "Manufactured Material" lists pre-

76 M R 1.

CANADIAN PACIFIC RAILWAY.
LINES EAST OF FORT WILLIAM.
MOTIVE POWER DEPARTMENT.

MAINTENANCE REGULATION 76 M R 1.
TYRE LIMIT OF WEAR AND THICKNESS.
ISSUE NO. 4 MARCH 2, 1907.

Tyre.	Type of locomotive.	Service.	Weight on pair of wheels.	Thickness at final turning.	Maximum depth of groove. After final turning	After other turnings
Driving.	All Types.	Pass.	30000 lb. or over	2 inches.	3-16 inch.	1-4 inch.
Driving.	All Types.	Pass.	Under 30000 lb.	1 3-4 inch.	3-16 inch.	1-4 inch.
Driving.	Mogul.	Freight	All weights.	1 5-8 inch.	1-4 inch.	1-4 inch.
Driving.	Consolidation.	Freight	All weights.	1 3-4 inch.	1-4 inch.	1-4 inch.
Driving.	10 Wheel.	Freight	All weights	1 5-8 inch.	1-4 inch.	5-16 inch.
Driving.	8 Wheel.	Freight	All weights.	1 1-2 inch.	1-4 inch.	5-16 inch
Driving.	Switch.	Switch	30000 lb. or over	1 1-2 inch.	1-4 inch.	3-8 inch.
Driving.	Switch.	Switch	Under 30000 lb.	1 3-8 inch.	1-4 inch.	3-8 inch.
Eng. Truck	All Types.	All.	All weights.	1 3-8 inch.	1-8 inch.	3-16 inch.
Ten. Truck	All Types.	All.	All weights.	1 3-8 inch.	1-8 inch.	3-16 inch.

Engine and tender truck wheels must be taken out of service when tyres are less than 1 1-4 inch thick.

FIG. 15.—THE "MAINTENANCE REGULATION" CARD FOR THE LIMIT OF WEAR OF TIRES.

viously described, must also have a means of providing for just such contingencies. For this work a "Change in Progress" system has been adopted, consisting of three parts, as follows:

1. A means of keeping the official who has charge of the locomotives posted as to exactly what changes he is expected to make on each class, when they are to be made, and a reference to the prints which show these changes in detail.

2. A means by which the official who has charge of the work can report in a clear and concise manner, the time at which it is completed on each locomotive.

CANADIAN PACIFIC RAILWAY CO.

MOTIVE POWER DEPARTMENT.

Mr. .... Montreal, *August 15th*, 1907.

.... Manifest No. *300*.

I furnish you herewith, Issue to *G. R.*

Drawing No.	Subject.	Remarks.	Application
51 L 134	*Combination lever for Walschaert Valve Gear, Class M4h.*	*Oil hole for radius bar pin and valve stem crosshead pin increased from 1/8" to 1/4" dia.*	*Immediately.*

Kindly acknowledge receipt of these drawings and that same are thoroughly understood, on attached form; also arrange to destroy all previous copies of the above drawings as soon as existing requirements will allow.

CORRECT. APPROVED.

....

MECHANICAL ENGINEER. ASST. SUPT. MOTIVE POWER.

CANADIAN PACIFIC RAILWAY CO.

..........................190

Asst. Supt. Motive Power.

The drawings shown on Manifest No. ....dated ....have been received, and instructions on Manifest are fully understood.

Signed. ....

FIG. 16.—FORM USED IN CONNECTION WITH CHANGES AND REVISIONS OF DRAWINGS.

3. A means by which the drawing office can keep a record of each engine changed, and on what date, until they have all been changed when the old record may be entirely superseded and a new permanent record made.

Full information as to the changes to be made is first issued to the shops or roundhouses which will do the work, by means of drawings showing the new part or parts to be applied or by a revision notice if the change is not of a complicated nature; in either case the blue prints thus supplied are issued on the manifest form shown in Fig. 16, accompanied by a sheet giving a list of all the changes which are to be made. This sheet is called a "List of Changes in Progress" and fulfils the conditions of the first part of the system, being issued for the purpose of keeping in an accessible, compact form a list of all changes which are to be made on different classes of locomotives.

The lists are printed on 8½ x 12 in. (size A) sheets, arranged to be bound in standard binders; one of these sheets is shown in Fig. 17, the first column headed "Item" being filled in with consecutive numbers which are used as a reference to the information contained on the different lines. The second column contains the sub-class or exact designation of the locomotives in question, while the third, fourth and sixth contain the title, number of the drawing and the date on which the revision or addition was issued; in the fifth column, headed "Application," is filled in the time at which the work is to be done, as "Immediately," "First Shopping," etc., conforming with the manifest.

Only one class of locomotive may be shown on a sheet, so that reference to the book in which these sheets are bound by classes shows the official in charge of the work exactly what is to be done to each. To insure these sheets being kept up to date, a new one is always sent out with each additional revision, the previous sheets issued being destroyed.

The second condition of the system, or means of reporting the changes made, is fulfilled by the form shown in Fig. 18, which is headed "Report of Changes in Progress." A supply of these forms is kept at each repair shop and as soon as any changes have been made to a locomotive a report blank is filled out, separate sheets being used for each. The first five columns are filled in exactly as on the "List of Changes in Progress," the item numbers corresponding, which gives a reference from one sheet to the other; the sixth column shows the date on which the work was completed. These sheets, being correctly filled in and sent to the drawing office, make it possible to keep an accurate record, engine by engine, as the work progresses, even though it should be scattered over a period of months.

The third condition of the system, or means by which an accurate record can be kept of each locomotive changed, is accomplished by the form shown in Fig. 19, which is called "Record of Changes in Progress." These sheets are also bound, arranged by classes, in 8½ x 12 in. binders, each showing only locomotives of one class, the numbers of which are filled in consecutively under the heading "Locomotive No." The slanted extensions to the vertical columns are filled in with the item numbers and names of the changes applying to the class of locomotive shown on the sheet, the item numbers corresponding to those on the "List of Changes" which was sent out with the manifest and instructions for doing the work.

On receipt of a report form showing that certain changes have been made to a locomotive, the proper column is located on the record sheet by means of the item number and name of the revision; the date on which the change was made as taken from the report sheet is then entered in it opposite the locomotive number and as soon as all the locomotives of that class are shown as being changed the record for that particular item is complete, the old drawings may be superseded and the new ones marked up for the complete class. Reference to the notations on the sheets, Figs. 17, 18 and 19, shows very clearly how the work is followed up.

CAN. PAC. RY.

LIST OF CHANGES IN PROGRESS CLASS *M4*

ITEM NO.	SUB CLASS	TITLE	DRAWING NO.	APPLICATION	DATE ISSUED
1	M4a-h	Equalizer Hanger	09L 20	Renewals	Feb. 21st 1905
2	M4a-h	Eccentric Rod	33L 8	Immediatly	Dec. 14th 1905
3	M4a-h	Front Cylinder Head Safety Groove	28L 72	1st Shopping & Renewals	May 23rd 1906
4	M4h	Combinaion Lever	51L 134	Immediatly	Aug. 15th 1907

FIG. 17.—FORM SHOWING LIST OF CHANGES IN PROGRESS.

CAN. PAC. RY.

REPORT OF CHANGES IN PROGRESS

LOCO. NO. *1665* CLASS *M4*

ITEM NO.	SUB CLASS	TITLE	DRAWING NO.	APPLICATION	DATE CHANGED
4	M4h	Combinaion Lever	51L 134	Immediatly	Aug. 29th 1907

FIG. 18.—REPORT FORM FOR CHANGES IN PROGRESS.

Receipts for Prints.—A special form of receipt used for miscellaneous print or other issues is shown in Fig. 20. These are used as a reply to a request for prints, etc., and when returned properly signed, form a record that the prints asked for were received by the person addressed.

These receipts are printed in books containing one hundred blank forms with plain sheets underneath, to which any notations made on the top sheet are transmitted by carbon paper; the top sheets are perforated and may be detached to send out with the prints, the duplicate which remains in the book serving as the record showing that the request has been attended to. The originals when properly receipted and returned are indexed and filed, so as to be readily located, if necessary to prove that certain prints were issued.

CAN. PAC. RY.

LOCOMOTIVES 1661-70 RECORD OF CHANGES IN PROGRESS

CLASS M4h

Equalizer Hanger Drawing No. 69L20 — Eccentric Rod Drawing No. 33L8 — Front Cylinder Head Safety Groove Drg. No. 28L72 — Combination Lever Drawing No. 51L134

LOCO NO	Item 1	Item 2	Item 3	Item 4			
1661	Mch.1,05	Dec.20,05	Jun.29,06	Sep.29,07			
1662	Apl.10,05	Dec.26,05	Oct.20,06	Oct.15,07			
1663	Jun.16,05	Jan.5,06		Nov.1,07			
1664	Jun.7,05	Dec.29,05					
1665	Apl.18,05	Apl.13,06	Aug.5,06	Aug.29,07			
1666	Jun.20,05	Mch.5,06	Sep.15,06				
1667	Nov.1,05	Jan.3,06		Aug.25,07			
1668	Sep.8,05	Dec.26,05	Dec.7,06	Sep.1,07			
1669	Apl.5,05	Mch.1,06					
1670	Aug.16,05	Jan.15,06	Jan.6,07	Oct.5,07			

FIG. 19.—FORM FOR KEEPING RECORD OF CHANGES IN PROGRESS.

Material Lists for New Equipment.—As a large part of the locomotives and other equipment required by the Canadian Pacific Railway is built at its own shops, all of it being to the company's design, a short description of the material and drawing record lists may be of interest. For each order of locomotives built, it is necessary to place requisitions on the purchasing department which will show exactly what material is required and how much, with full particulars as to size, quality, etc.

As the material required to build a locomotive may be divided into three main groups, each containing approximately the same number of items, namely, gray iron castings, brass castings and general material, three books may very conveniently be used, one each for gray iron castings and brass castings, sample sheets of which are shown in Figs. 21 and 22, respectively, and one for general material, as shown by Fig. 23, which contains a record of all the other material used, such as tires, boiler and tank plates, steel and malleable castings, etc.

It is preferable that these books be arranged to show the material required for one locomotive, as in the case of duplicate orders it is only necessary to multiply by the number of locomotives in the order, when making out the requisitions. Reference to the sample sheets, Figs. 21 and 22, show that spaces are provided for the date of entry which is also the date on which the order is placed, the name and pattern number of the casting, number of the drawing on which it is shown, and its weight which is useful both for comparison and for checking the amount of material contained in the order. The list also shows the dates on which the foundry will have to deliver the first and last castings in order to keep up with the schedule arranged for the completion of the locomotives; of the three remaining columns that headed "Item" which is filled in with consecutive numbers is used for convenience in referring to the casting shown in that particular line. "Check" is used for the checkers initials and "Remarks" for any miscellaneous information, such as the location of pattern, revision notes, etc.

The record in the general material list, shown in Fig. 23, is very complete and contains full particulars as to the size, quantity, material, etc., of the parts on order, spaces being provided for "Item," quantity required for one locomotive and date of entry, all of which are filled in similarly to the casting list.

The column headed "Description of Material" is outlined in such a manner as to necessitate only the addition of a few figures, etc., to complete a full description of the part required. That headed "Delivery Asked" is filled in with the date on which it will be necessary to have the material at the shops to keep up with the building schedule, while the two remaining columns "Ordered From" and "Stores Order Number," are filled in with the name of the firm on which the order has been placed and the number of the stores department order.

These lists are arranged by the elevation draughtsman in charge of the design, entries being made by him as the work progresses and when sufficient information has been worked up the books are turned over to the requisition clerk who makes out the orders.

The books are also convenient as an office record containing, as they do, particulars of every part entering into the construction of each locomotive. They may also be issued to the shops for guidance during the performance of the work. "Drawing Record Lists," as shown by Fig. 24, are made to show the numbers and titles of all drawings used on the locomotives to be built. They also show the date on which the prints were issued to the shops and other information of a similar nature.

This general description covers the principal parts of the drawing office system used in the motive power department of the Canadian Pacific Railway, which was worked out under the direct supervision of H. H. Vaughan, assistant to the vice-president, by L. R. Johnson, assistant superintendent of motive power, and A. W. Horsey, mechanical engineer.

The system has been in operation several years with uniformly satisfactory results, practically no changes having been found necessary in the original scheme.

CANADIAN PACIFIC RAILWAY CO.

OFFICE MECHANICAL ENGINEER

No. *MONTREAL* 190 .

Mr.

Dear Sir:—

Complying with your

I send you herewith drawings mentioned below for which kindly sign and return this sheet.

Yours truly,

A. W. HORSEY,

Mechl. Engr.

DRAWING No.	TITLE

Received the above drawings to-day in good order.

DATE

FIG. 20.—FORM OF RECEIPT FOR MISCELLANEOUS BLUE PRINTS.

CANADIAN PACIFIC RAILWAY
MOTIVE POWER DEPT.
IRON CASTINGS

CLASS_____ROAD NOS.______APPROPIATION NO.______BUILT_______19____
CLASS_____ROAD NOS.______APPROPIATION NO.______BUILT_______19____
CLASS_____ROAD NOS.______APPROPIATION NO.______BUILT_______19____

ITEM	CHECK	DATE OF ENTRY	PIECES PER ENGINE	NAME OF CASTING	PATTERN NO.	DRAWING NO.	WEIGHT OF ONE PIECE	FIRST CASTING TO BE DELIVERED	LAST CASTING TO BE DELIVERED	REMARKS
1				*Eng. Truck Center Casting*	*34L*	*34L*				
2				*" " " Pin*	*34L*	*34L*				
3				*" " " Washer*	*34L*	*34L*				
4				*" " " Plate*	*34L*	*34L*				
5				*" " " Pedestal*	*34L*	*34L*				
6					*34L*	*34L*				

FIG. 21.—MATERIAL LIST FOR NEW EQUIPMENT—IRON CASTINGS.

CANADIAN PACIFIC RAILWAY
MOTIVE POWER DEPT.
BRASS CASTINGS

CLASS_____ROAD NOS.______APPROPIATION NO.______BUILT_______19____
CLASS_____ROAD NOS.______APPROPIATION NO.______BUILT_______19____
CLASS_____ROAD NOS.______APPROPIATION NO.______BUILT_______19____

ITEM	CHECK	DATE OF ENTRY	PIECES PER ENGINE	NAME OF CASTING	PATTERN NO.	DRAWING NO.	WEIGHT OF ONE PIECE	FIRST CASTING TO BE DELIVERED	LAST CASTING TO BE DELIVERED	REMARKS
1				*Try Cock Valve*	*24L*	*24L*				
2				*" " " Bodies*	*24L*	*24L*				
3				*" " " Stem bonnet*	*24L*	*24L*				
4				*" " " Dripper*	*24L*	*24L*				
5				*" " " Extension*	*24L*	*24L*				
6					*24L*	*24L*				

FIG. 22.—MATERIAL LIST FOR NEW EQUIPMENT—BRASS CASTINGS.

CANADIAN PACIFIC RAILWAY
MOTIVE POWER DEPT.
GENERAL MATERIAL

CLASS_____ROAD NOS.______APPROPIATION NO.______BUILT_______19____
CLASS_____ROAD NOS.______APPROPIATION NO.______BUILT_______19____
CLASS_____ROAD NOS.______APPROPIATION NO.______BUILT_______19____

ITEM	CHECK	NO. OF PIECES FOR ONE ENG.	DESCRIPTION OF MATERIAL	DATE OF ENTRY	DELIVERY ASKED	STORES ORDER NO.	ORDERED FROM
1			*Brake-Driver Style Drivers dia.*				
2			*Elevation Drg. No. Weight on Drivers lbs.*				
3			*" " Trailers lbs.*				
4			*Shoes on of wheels*				
5			*Special Equipment*				
6							

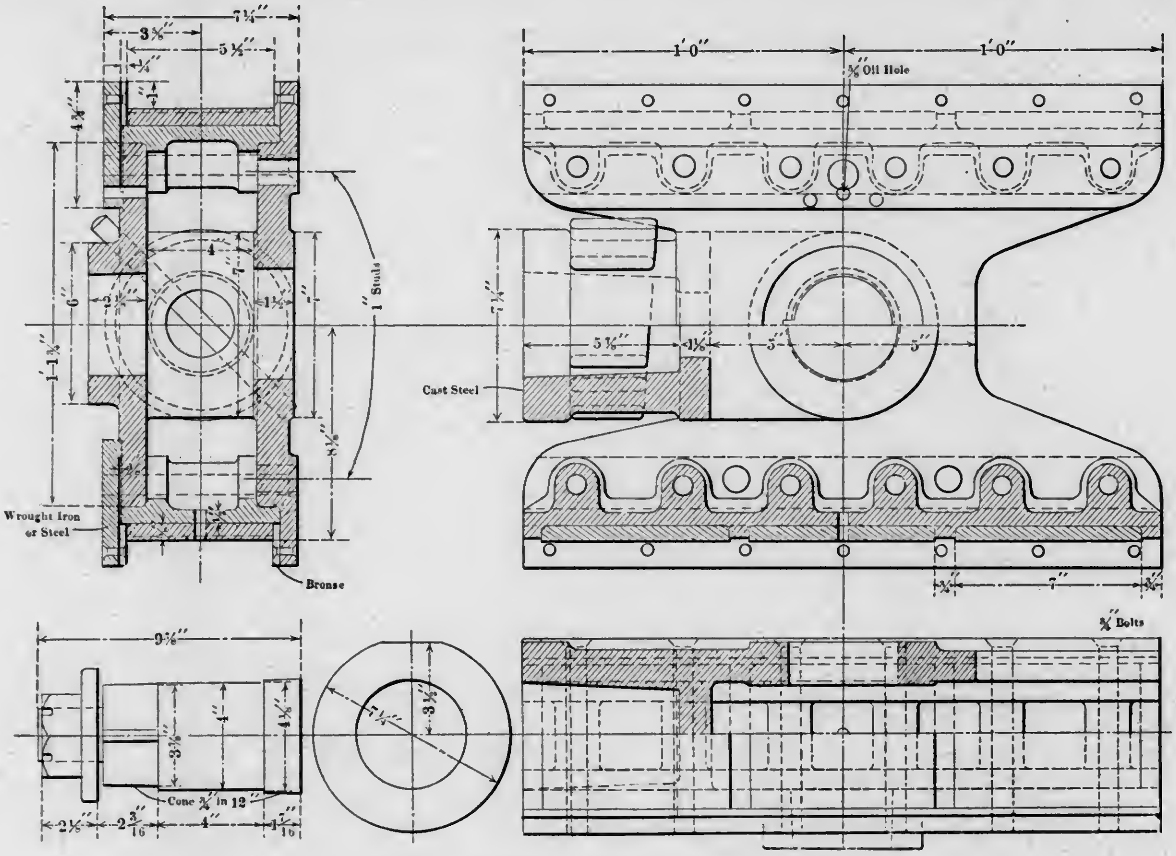
FIG. 23.—MATERIAL LIST FOR NEW EQUIPMENT—GENERAL MATERIAL.

CANADIAN PACIFIC RAILWAY
MOTIVE POWER DEPT.
DRAWING RECORD

CLASS_____ROAD NOS.______APPROPIATION NO.______BUILT_______19____
CLASS_____ROAD NOS.______APPROPIATION NO.______BUILT_______19____
CLASS_____ROAD NOS.______APPROPIATION NO.______BUILT_______19____

ITEM	CHECK	NAME OF DRAWING	DRAWING NO.	ISSUE TO SHOP: NO. OF PRINTS	ISSUE TO SHOP: DATE	REMARKS	ITEM	CHECK	NAME OF DRAWING	DRAWING NO.	ISSUE TO SHOP: NO. OF PRINTS	ISSUE TO SHOP: DATE	REMARKS
1		*Ash Pan*	*11L*				61		*Eng. Truck Box Brass*	*18L*			
2		*" " Air Hopper*	*11L*				62		*" " " Cellar*	*18L*			
3		*" " Axle guard*	*11L*				63		*" " " Liner*	*18L*			
4		*" " Butterfly Damper*	*11L*				64		*Trailing Truck Box*	*18L*			
5		*" " Cleaning Door*	*11L*				65		*" " " Brass*	*18L*			
6		*" " " Details*	*11L*				66		*" " " Dust guard*	*18L*			

FIG. 24.—DRAWING RECORD LIST FOR NEW EQUIPMENT.



ALLIGATOR CROSSHEAD—CANADIAN PACIFIC RAILWAY.

IMPROVED FORM OF ALLIGATOR CROSSHEAD.

CANADIAN PACIFIC RAILWAY.

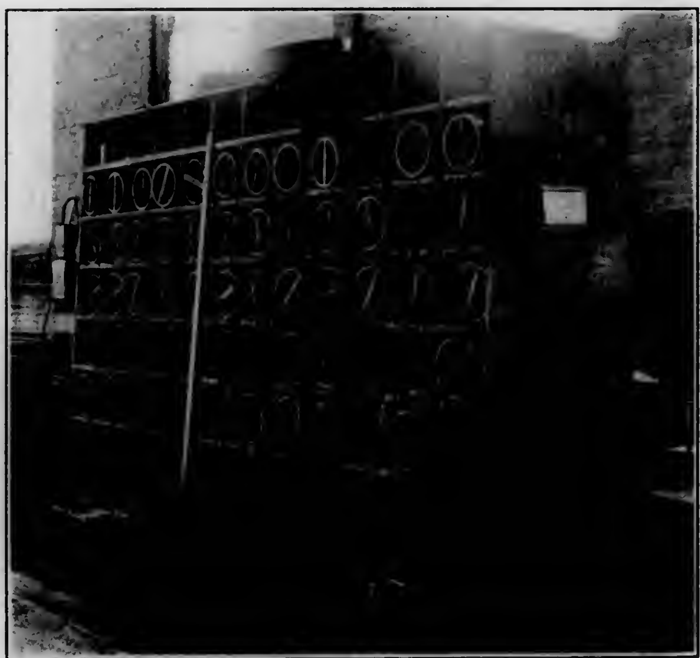
The alligator crosshead, shown in the drawing, has been experimented with on the Canadian Pacific Railway with very satisfactory results. The most important advantage is that the bearing strips or gibs, which may be made in one or more pieces (three shown on the drawing) can be lined up, or removed and replaced, at a comparatively small expense, it being unnecessary to disconnect the crosshead from the piston rod. All that has to be done is to slack off the nuts on the through bolts and remove the side plates. The slippers are of cast steel and divided by cross webs forming end checks for the gibs; the intermediate webs are removed when the gibs are made in one piece. The side plates when bolted up form a clamp to hold the gibs in place.

DRIVING BOX WORK AT THE GREAT NORTHERN RAILWAY SHOPS.

The driving box work at the Great Northern Railway shops in St. Paul is handled quite differently from the methods ordinarily in use at other shops. The boxes are first counter bored and babbitted on the hub side, after which the brass is pressed in by an air press; three brass pins are put in on the hub side, projecting a distance equal to the required thickness of the babbitt, and the box is filled with babbitt to this height, after which it is faced and bored on a 40-in. vertical boring mill.

The shoe and wedge faces are milled on a horizontal milling machine, no attention being paid to keeping these faces an equal distance from the center of the brass. In this way an unnecessary waste of material is prevented. In place of the ordinary inconvenient and laborious method of fitting each box to the journal upon which it is to be used, a set of mandrels has been provided, as shown in the illustration. These mandrels are hollow cast iron cylinders with a cross or center piece at each end so that they may be easily handled by the operator. The mandrels vary in size by 1/64 in. in diameter. All driving journals which are out of true 1/64 in. or more are re-turned. With these mandrels one man does all of the driving box fitting for the shop, and when the boxes leave his hands they are ready to be applied to the journals.

This operator, with the aid of a combination T square, which



MANDRELS FOR DRIVING BOX WORK AS USED AT THE ST. PAUL SHOPS, GT. NORTHERN RAILWAY.

has a sliding attachment for locating the center of the brass, quickly and accurately locates the lines for the shoe and wedge faces and the center of the brass. From this the shoe and wedge gang, composed of two machinists and helpers, take the dimensions and lay out the shoes and wedges for the entire shop.

DE GLEHN COMPOUND PACIFIC TYPE LOCOMOTIVE

PARIS-ORLEANS RAILWAY.

The Schenectady Works of the American Locomotive Company are completing an order of thirty Pacific type locomotives for the Paris-Orleans Railway of France, in which, from the standpoint of American practice, a number of novelties in design are introduced. The locomotives were built from designs and specifications furnished by the railway and are duplicates of some engines already in service and others being built by other companies. The drawings were dimensioned in the metric system and were not transposed on the shop drawings at Schenectady. The workmen found no difficulty in working with the metric system.

These engines will be used in fast express service on the division between Limoges and Brive, a distance of 61.27 miles, where the grades are long and heavy in both directions. Coming from Brive there is, with the exception of a few short level stretches, an almost continuous up grade, averaging about ¾ per cent. for a distance of 29.5 miles, while coming in the other direction, the road from Limoges to the summit of the rise is more undulating and the grades steeper, but shorter, the steepest grade being about .95 per cent. and 7.14 miles long. The fastest trains weigh from 330 to 360 English tons behind the tender, and make the run between Limoges and Brive in one hour and 29 minutes, including 16 stops, while from Brive to Limoges, with the same weight of train, the time is 8 minutes longer. To meet these requirements a powerful engine with a large boiler capacity for high speed is needed, and the engines here illustrated are designed to haul trains of 440 tons on a 1 per cent. grade at a speed of 30 miles per hour.

DE GLEHN COMPOUND PACIFIC TYPE LOCOMOTIVE FOR THE PARIS-ORLEANS RAILWAY.

The point of greatest novelty in the design is found in the firebox which, because of the desire to get a deep throat and avoid an excessive length of flue with three pairs of drivers driven by the De Glehn arrangement of balanced compound cylinders, is a combination of narrow type, between the frames, and the common wide type. It is 47.5 in. wide in front and 82.5 in. wide at the back end. In this way a grate area of 45.7 sq. ft. has been obtained in a firebox but 112 in. long inside. The manner of shaping the mud ring and flanging the side sheets to obtain this form is clearly shown in the illustrations.

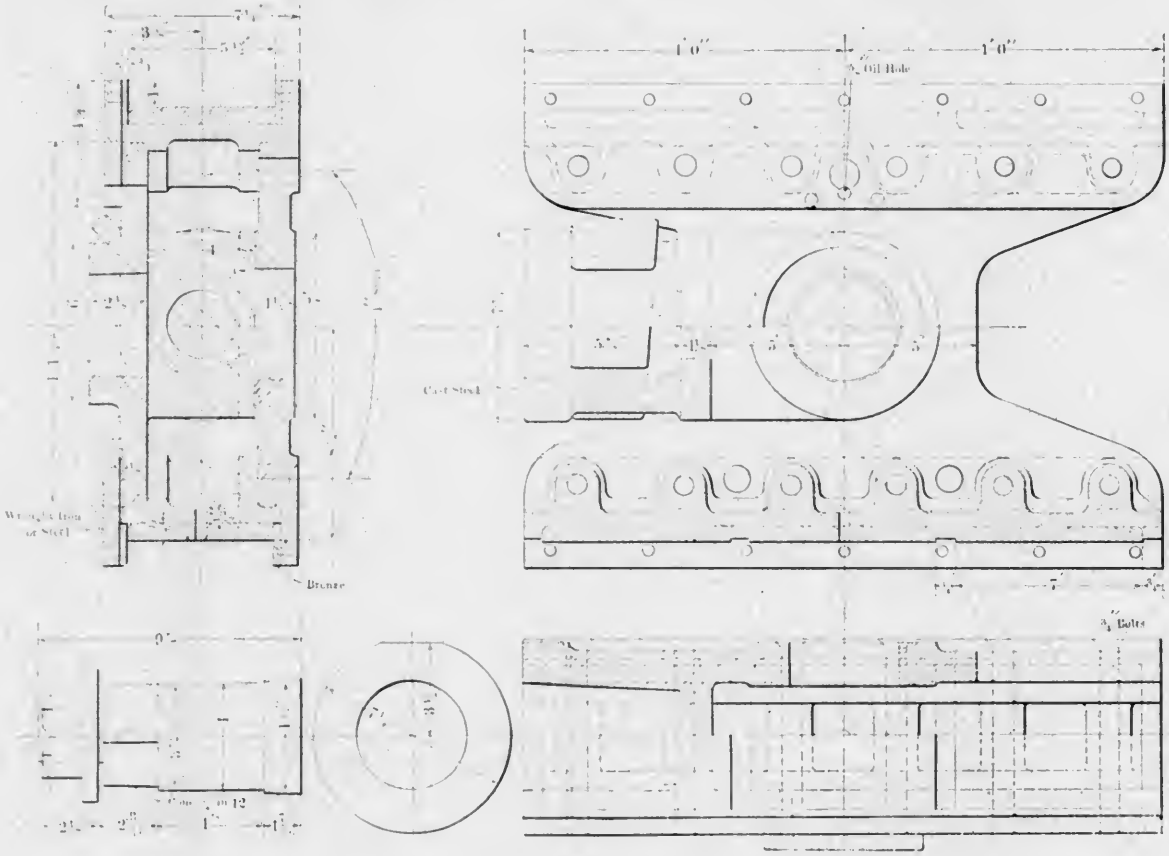
The De Glehn type of balanced compound locomotive is the common one in use for passenger service in France and has been tried in England and this country. It will be remembered that in 1904 the Pennsylvania Railroad purchased an Atlantic type locomotive of this design which was tested at the locomotive testing plant at St. Louis and has since been in regular service. This engine is reported to be very successful up to the limit of its capacity when handled by men who understand its operation. In brief the design comprises a four-cylinder compound in which the two high-pressure cylinders are outside the frames and located some distance back of the low-pressure cylinders, which are between the frames and directly below the smoke box. The high-pressure cylinders drive the second pair of drivers and the low-pressure the forward pair, which has a cranked axle. Each cylinder has an independent valve gear and the relations of the point of cut-off in the high and low-pressure pairs can be varied at the will of the engineer.

The steam pipes to the high-pressure cylinders are seamless drawn steel tubes, their connection to the cylinders being shown in the side elevation. Steam from the high-pressure cylinder exhausts into intercepting valves, located in chambers cast on the side of each low-pressure cylinder, directly beneath the steam chests. These valves are in the form of hollow cylinders forming a recess and have suitable openings cut in them, which, according to the position of the valve, allow the high-pressure exhaust to pass to the low-pressure steam chests and receiver, or to the atmosphere, through a direct exhaust passage cored out in the front of the low-pressure cylinder castings. These valves are operated by air pressure, controlled from the cab, the air cylinder being located between the frames just ahead of the low-pressure cylinders, and the ends of the piston rod being connected to crank arms on the ends of the intercepting valve stems.

Steam direct from the dome is admitted to the low-pressure steam chests and receiver in starting or when working simple, by means of a valve located on the back-head of the boiler, which, when opened, allows steam to flow through a small copper pipe, extending from it through the front tube sheet and connecting to the copper pipe, shown in the side elevation, which connects to an opening in the receiver on the right side of the exhaust pipe. Another copper pipe connected to a similar opening in the receiver on the left side of the exhaust pipe extends out through the side of the smoke box and is provided with a relief valve which regulates the pressure of steam in the receiver. By this arrangement of connections and valves it is possible to operate either the high or low-pressure cylinders alone, either independently or in conjunction with each other.

Most of the previous examples of the De Glehn compound have the steam pipes passing down outside the boiler shell directly to the high-pressure cylinders. In this case, however, the steam pipes are in their usual location in the front end and are continued by a short outside pipe to the front of the high-pressure cylinders.

Walschaert valve gear is used on both cylinders; the outside gear being operated by a return crank on the second pair of drivers and the inside by eccentrics on the cranked axle. The two reach rods are on the left side, located one behind the other. A screw reverse gear, which is arranged to permit the independent operation of the two sets of valve gear or to operate them together at a set ratio of cut-offs as desired, is placed on the left side in front of the engineer's seat. The throttle lever, which



ALLIGATOR CROSSHEAD—CANADIAN PACIFIC RAILWAY.

IMPROVED FORM OF ALLIGATOR CROSSHEAD.

CANADIAN PACIFIC RAILWAY.

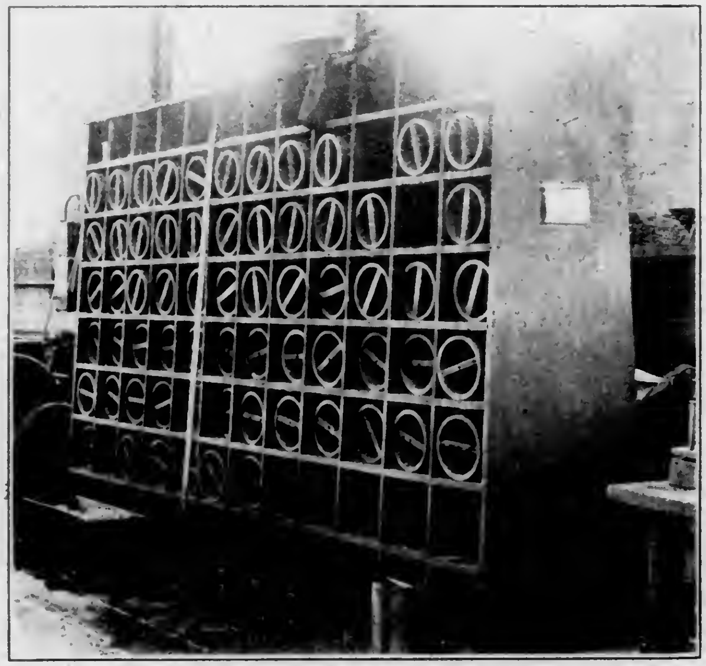
The alligator crosshead, shown in the drawing, has been experimented with on the Canadian Pacific Railway with very satisfactory results. The most important advantage is that the bearing strips or gibs, which may be made in one or more pieces (three shown on the drawing) can be lined up, or removed and replaced, at a comparatively small expense, it being unnecessary to disconnect the crosshead from the piston rod. All that has to be done is to slack off the nuts on the through bolts and remove the side plates. The slippers are of cast steel and divided by cross webs forming end checks for the gibs; the intermediate webs are removed when the gibs are made in one piece. The side plates when bolted up form a clamp to hold the gibs in place.

DRIVING BOX WORK AT THE GREAT NORTHERN RAILWAY SHOPS.

The driving box work at the Great Northern Railway shops in St. Paul is handled quite differently from the methods ordinarily in use at other shops. The boxes are first counter bored and babbitted on the hub side, after which the brass is pressed in by an air press; three brass pins are put in on the hub side, projecting a distance equal to the required thickness of the babbitt, and the box is filled with babbitt to this height, after which it is faced and bored on a 40-in. vertical boring mill.

The shoe and wedge faces are milled on a horizontal milling machine, no attention being paid to keeping these faces an equal distance from the center of the brass. In this way an unnecessary waste of material is prevented. In place of the ordinary inconvenient and laborious method of fitting each box to the journal upon which it is to be used, a set of mandrels has been provided, as shown in the illustration. These mandrels are hollow cast iron cylinders with a cross or center piece at each end so that they may be easily handled by the operator. The mandrels vary in size by 1/64 in. in diameter. All driving journals which are out of true 1/64 in. or more are re-turned. With these mandrels one man does all of the driving box fitting for the shop, and when the boxes leave his hands they are ready to be applied to the journals.

This operator, with the aid of a combination T square, which



MANDRELS FOR DRIVING BOX WORK AS USED AT THE ST. PAUL SHOPS, GT. NORTHERN RAILWAY.

has a sliding attachment for locating the center of the brass, quickly and accurately locates the lines for the shoe and wedge faces and the center of the brass. From this the shoe and wedge gang, composed of two machinists and helpers, take the dimensions and lay out the shoes and wedges for the entire shop.

DE GLEHN COMPOUND PACIFIC TYPE LOCOMOTIVE

PARIS-ORLEANS RAILWAY.

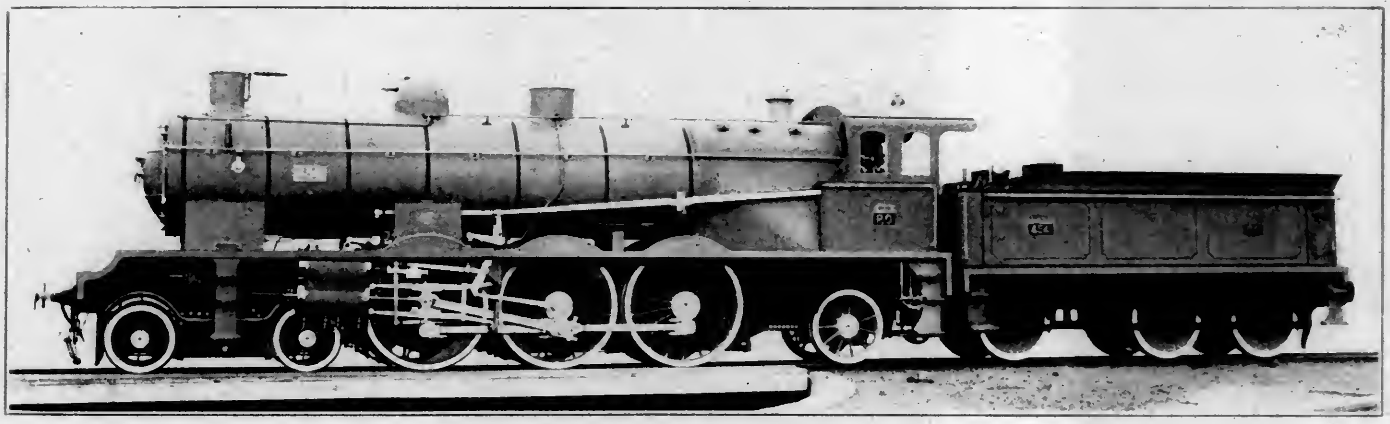
The Schenectady Works of the American Locomotive Company are completing an order of thirty Pacific type locomotives for the Paris-Orleans Railway of France, in which, from the standpoint of American practice, a number of novelties in design are introduced. The locomotives were built from designs and specifications furnished by the railway and are duplicates of some engines already in service and others being built by other companies. The drawings were dimensioned in the metric system and were not transposed on the shop drawings at Schenectady. The workmen found no difficulty in working with the metric system.

These engines will be used in fast express service on the division between Limoges and Brive, a distance of 61.27 miles, where the grades are long and heavy in both directions. Coming from Brive there is, with the exception of a few short level stretches, an almost continuous up grade, averaging about ¾ per cent. for a distance of 29.5 miles, while coming in the other direction, the road from Limoges to the summit of the rise is more undulating and the grades steeper, but shorter, the steepest grade being about .95 per cent. and 7.14 miles long. The fastest trains weigh from 330 to 360 English tons behind the tender, and make the run between Limoges and Brive in one hour and 20 minutes, including 16 stops, while from Brive to Limoges, with the same weight of train, the time is 8 minutes longer. To meet these requirements a powerful engine with a large boiler capacity for high speed is needed, and the engines here illustrated are designed to haul trains of 440 tons on a 1 per cent. grade at a speed of 30 miles per hour.

The point of greatest novelty in the design is found in the firebox which, because of the desire to get a deep throat and avoid an excessive length of flue with three pairs of drivers driven by the De Glehn arrangement of balanced compound cylinders, is a combination of narrow type, between the frames, and the common wide type. It is 47.5 in. wide in front and 82.5 in. wide at the back end. In this way a grate area of 45.7 sq. ft. has been obtained in a firebox but 112 in. long inside. The manner of shaping the mud ring and flanging the side sheets to obtain this form is clearly shown in the illustrations.

The De Glehn type of balanced compound locomotive is the common one in use for passenger service in France and has been tried in England and this country. It will be remembered that in 1904 the Pennsylvania Railroad purchased an Atlantic type locomotive of this design which was tested at the locomotive testing plant at St. Louis and has since been in regular service. This engine is reported to be very successful up to the limit of its capacity when handled by men who understand its operation. In brief the design comprises a four-cylinder compound in which the two high-pressure cylinders are outside the frames and located some distance back of the low-pressure cylinders, which are between the frames and directly below the smoke box. The high-pressure cylinders drive the second pair of drivers and the low-pressure the forward pair, which has a cranked axle. Each cylinder has an independent valve gear and the relations of the point of cut-off in the high and low-pressure pairs can be varied at the will of the engineer.

The steam pipes to the high-pressure cylinders are seamless drawn steel tubes, their connection to the cylinders being shown in the side elevation. Steam from the high-pressure cylinder exhausts into intercepting valves, located in chambers cast on the side of each low-pressure cylinder, directly beneath the steam chests. These valves are in the form of hollow cylinders forming a recess and have suitable openings cut in them, which, according to the position of the valve, allow the high-pressure exhaust to pass to the low-pressure steam chests and receiver, or to the atmosphere, through a direct exhaust passage cored out in the front of the low-pressure cylinder castings. These valves are operated by air pressure, controlled from the cab, the air cylinder being located between the frames just ahead of the low-pressure cylinders, and the ends of the piston rod being connected to crank arms on the ends of the intercepting valve stems.

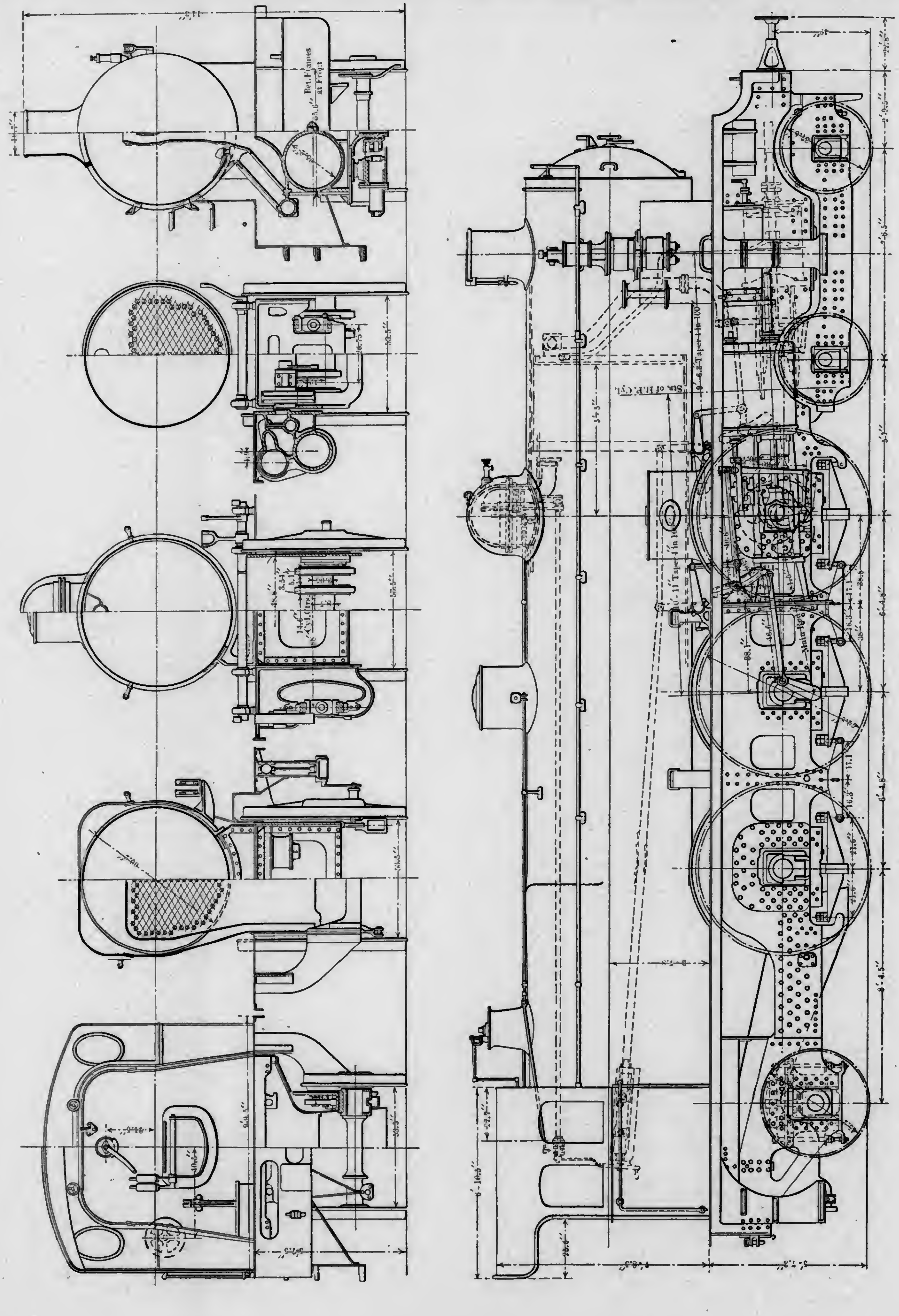


DE GLEHN COMPOUND PACIFIC TYPE LOCOMOTIVE FOR THE PARIS-ORLEANS RAILWAY.

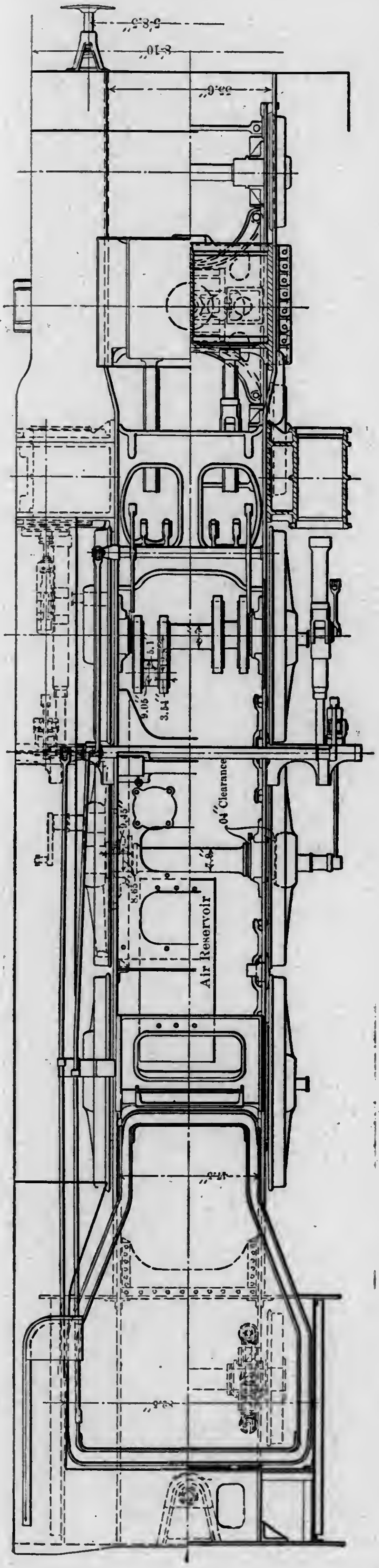
Steam direct from the dome is admitted to the low pressure steam chests and receiver in starting or when working simple, by means of a valve located on the back head of the boiler, which, when opened, allows steam to flow through a small copper pipe, extending from it through the front tube sheet and connecting to the copper pipe, shown in the side elevation, which connects to an opening in the receiver on the right side of the exhaust pipe. Another copper pipe connected to a similar opening in the receiver on the left side of the exhaust pipe extends out through the side of the smoke box and is provided with a relief valve which regulates the pressure of steam in the receiver. By this arrangement of connections and valves it is possible to operate either the high or low pressure cylinders alone either independently or in conjunction with each other.

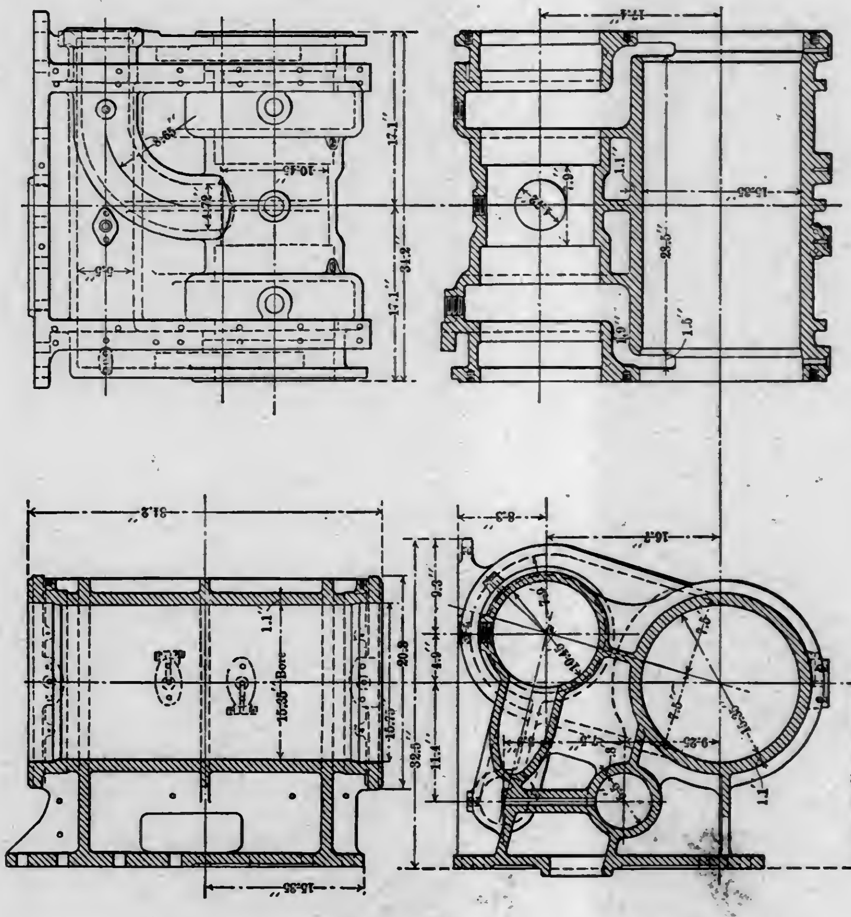
Most of the previous examples of the De Glehn compound have the steam pipes passing down outside the boiler shell directly to the high-pressure cylinders. In this case, however, the steam pipes are in their usual location in the front end and are continued by a short outside pipe to the front of the high-pressure cylinders.

Walschaert valve gear is used on both cylinders; the outside gear being operated by a return crank on the second pair of drivers and the inside by eccentrics on the cranked axle. The two reach rods are on the left side, located one behind the other. A screw reverse gear, which is arranged to permit the independent operation of the two sets of valve gear or to operate them together at a set ratio of cut-offs as desired, is placed on the left side in front of the engineer's seat. The throttle lever, which

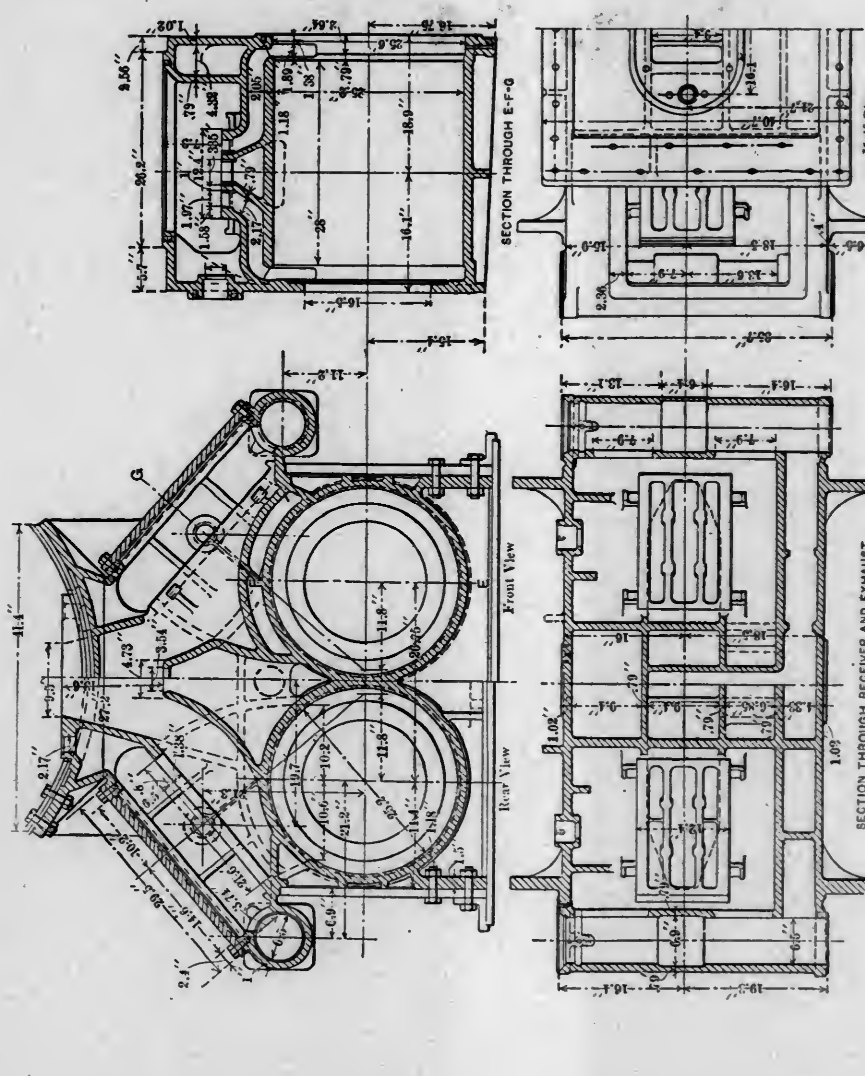


PARIS-ORLEANS DE GLEHN COMPOUND PACIFIC TYPE LOCOMOTIVE.





HIGH PRESSURE CYLINDER AND VALVE CHAMBER CASTING.



LOW PRESSURE CYLINDERS.

operates in a vertical plane instead of horizontally, as is universal American practice, is placed on the back head, the rod from the valve being inside the boiler and passing through a stuffing box at this point. In connection with the valve gear it will be noticed that the valve chambers of the high-pressure cylinders are set outside the cylinders so as to give a direct drive from the return crank, while with the inside gears there is a difference of nearly 14 inches between the plane of the valve stem and that of the eccentric. This offset is provided by means of an extended trunnion on the link with a downwardly extending arm at the end. To prevent any springing at this point the links have liberal supports at three points.

The details of the cylinder castings are shown in one of the illustrations. The high-pressure cylinders with the piston valve chambers are in separate castings, which are bolted to the plate frames just ahead of the front driving wheels. The steam passage continued from the front by a bend of large radius to the center of the valve chamber, and the exhaust passages, which are, of course, separated from entering steam by air spaces, emerge just below it and are continued to the receiver by a short section of heavily lagged piping. The castings are made as light as possible and of the best grade of grey iron. All passages are made individual as far as possible and stayed by ribs to each other and the main casting.

The two low-pressure cylinders, together with the saddle and their steam chests and receiver are in one casting. They set between the frames which are widened at this point to permit the use of 25.2 in. diameter cylinders. The low-pressure valves are of bronze and of the plain unbalanced slide type. They have inclined seats and extend slightly over the top of the frames. The passages throughout are very large and give free movement to the steam. In order to provide clearance for the front truck, all the cylinders are slightly inclined.

The boiler is also shown in detail in one of the illustrations. It is of the straight top type with Belpaire firebox, the firebox being copper. All the stays in the water legs are of manganese bronze, while the crown and boiler stays are of Falls Hollow stay bolt iron. The barrel is made up of sheets about .79 in. in thickness, there being three rings. The front tube sheet, which is nearly 1 in. thick, is flanged and set into the front course sheet. It is braced above the flues by two horizontal plates about 14 in. wide and .63 in. thick.

The dome construction is somewhat unusual and consists of a lower section of .6 in. steel flanged to fit the boiler, and a hemispherical upper section of the same material. The two are joined by a flange, the arrangement being such that the upper sheet fits inside the flange on the lower section in the manner shown in the illustration. The dome is set 65 in. back of the tube sheet.

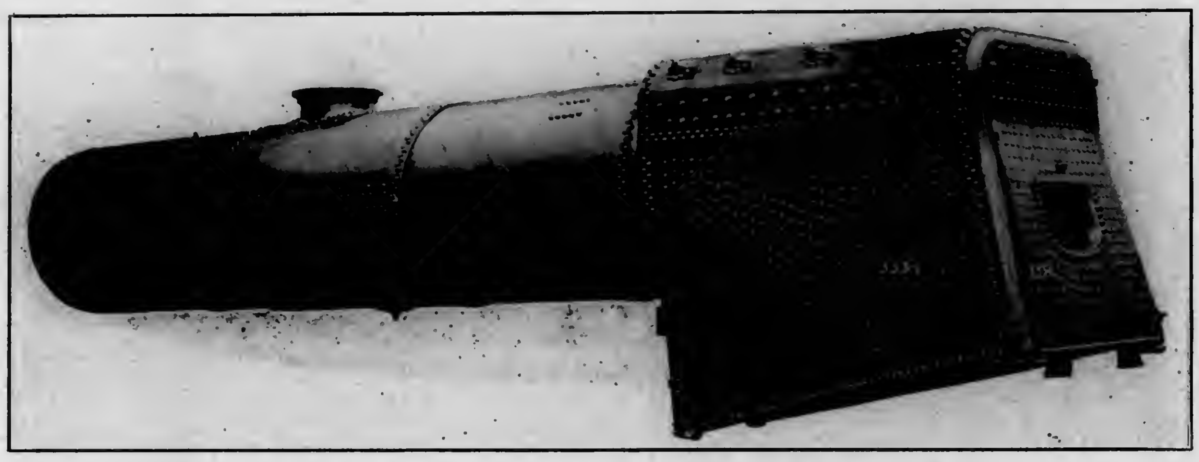
The boiler contains 261 tubes 2.165 in. in diameter, which are set at 2.84 in. centers. They have a drop of about two inches toward the firebox. The back tube sheet of copper is 1.18 in. thick where the tubes enter and is narrowed to .63 in. thick at the throat, where it is held by stays. The throat is 37.9 in. deep and the water space is 3.74 in. at the mud ring. The crown sheet has a slope of about 2 in. toward the rear and is made of copper .63 in. thick. It will be noted that the back head braces are all fitted with nuts for correct distribution of the stresses after the boiler is erected.

The grate has a very decided slope, the difference in level being 21.7 in. The door opening is of peculiar shape, shown in the illustration. It is 27.5 in. wide and 15.75 in. high. The back firebox sheet is dished at the door to permit the use of a door ring only 2.36 in. wide.

The method of setting the tubes is also shown in the illustration. The hole in the back sheet is taper and the tube is swaged down to enter and is rolled and beaded. The holes in the front sheet are straight, 2.24 in. in diameter and the tube is simply expanded and rolled.

The smoke-box is provided with a high exhaust pipe fitted with a variable exhaust nozzle. This device consists of a hollow cone fitted in the top of the exhaust pipe, the largest outside diameter of which is equal to the inside diameter of the tip of the nozzle. This cone is connected to the horizontal arm of a shaft which extends out of the side of the smoke-box, and is operated from the cab by means of a screw and hand wheel. By lowering or raising the cone, the amount of the exhaust opening is increased or diminished.

The blower nozzle, of bronze, is a hollow ring surrounding the exhaust nozzle and provided with a number of holes in its upper face. A sprinkling device is also provided in the smoke-box for extinguishing hot cinders. The smoke-stack is of cast iron, and is provided with a hood, by means of which the draft may be checked when the engine is standing in a station or drifting.

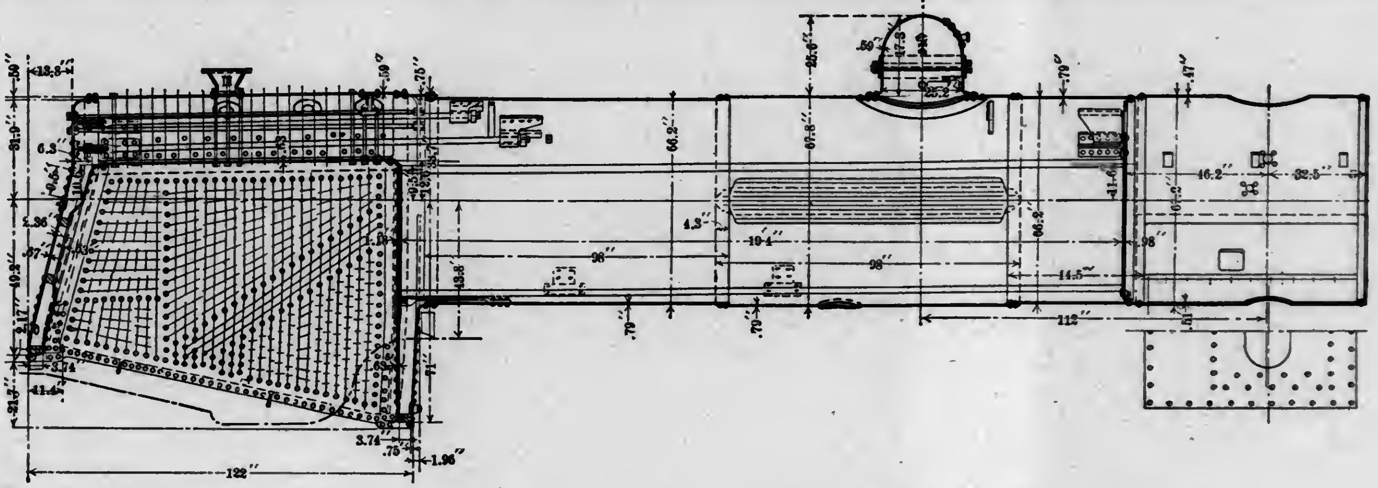


BOILER FOR THE DE GLEHN COMPOUND PACIFIC TYPE LOCOMOTIVE.

The frames are of steel plate in two sections, the main frames being 1.26 in. thick, and the rear section for the trailing truck being 1.18 in. thick. A good depth of plate is provided over the pedestals. They are very strongly tied together, the location and arrangement of the bracing being shown in the elevation and cross sections. The low-pressure guides and also the low-pressure link supports are bolted to the heavy steel box casting between the high-pressure cylinders. The outside guides and high-pressure link supports are bolted to cast steel guide yokes secured to the frames. All the axles are forged steel, the crank axle being a single forging. The driving boxes are also of forged steel.

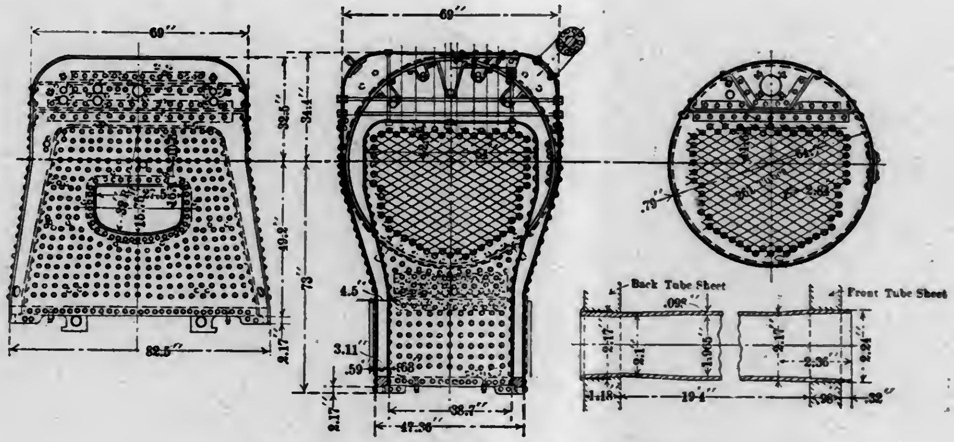
The three pairs of driving wheels are equalized together, the under-hung spring system being employed. Contrary to American practice in this type of engine, however, the trailing truck is not equalized with the driving wheels. It is of the side motion type with inside bearings, lateral motion being provided by 3.55 in. play between the boxes and pedestals on each side, and the load on the truck is utilized to bring it back to its central position.

The front engine truck is the Paris-Orleans standard design, all the weight being transferred to it by means of two hemispherical side bearings seated in castings which can slide on the



cast steel center frame. The truck is brought back to its central position after leaving a curve by means of two transverse coil springs, one on either side of the center plate.

The tender tank is of the water bottom type and has a water capacity of 5,300 gallons. It is provided with three gauge cocks on the left side to show the level of the water in the tank. The tender frame consists of two steel plate side frames, placed outside of the wheels and strongly braced together. The tender is carried on six wheels and the weight is transmitted to the journal boxes through semi-elliptic springs over the top of each box, the two rear pairs of wheels being equalized together.



BOILER—DE GLEHN COMPOUND LOCOMOTIVE.

The general dimensions, weights and ratios are as follows:

GENERAL DATA.

Gauge	4 ft. 9 in.
Service	Passenger
Fuel	Coal
Tractive effort	24,940 lbs.
Weight in working order	195,000 lbs.
Weight on drivers	122,000 lbs.
Weight of engine and tender in working order	294,800 lbs.
Wheel base, driving	12 ft. 9.54 in.
Wheel base, total	34 ft. 5.4 in.
Wheel base, engine and tender	58 ft. 5.2 in.

RATIOS.

Weight on drivers ÷ tractive effort	4.9
Total weight ÷ tractive effort	7.8
Tractive effort × diam. drivers ÷ heating surface	597.0
Total heating surface ÷ grate area	66.5
Firebox heating surface ÷ total heating surface, per cent	6.1
Weight on drivers ÷ total heating surface	40.2
Total weight ÷ total heating surface	61.1
Volume equiv. simple cylinders, cu. ft	8.0
Total heating surface ÷ vol. cylinders	380.0
Grate area ÷ vol. cylinders	5.7

CYLINDERS.

Kind	DeGlehn Comp.
Diameter and stroke	15.35 and 25.2 × 25.6 in.

VALVES.

Kind	H. P.-Piston, L. P.-Slide
Greatest travel	H. P.-5.25 in., L. P.-5.7 in.
Outside lap	H. P.-1.06, L. P.-1.06 in.
Inside lap	H. P.-.118, L. P.-.197 in.

WHEELS.

Driving, diameter over tires	72.8 in.
Driving journals, diameter and length	8.65 × 9.45 in.
Engine truck wheels, diameter	37.8 in.
Engine truck, journals	5.9 × 9.85 in.
Trailing truck wheels, diameter	45.2 in.
Trailing truck, journals	7.1 × 11.8 in.

BOILER.

Style	Belpaire
Working pressure	227.6 lbs.
Outside diameter of first ring	66.2 in.
Firebox, length	112 in.
Firebox, width	F.-38.8, B.-74 in.
Firebox plates, thickness	.63 in.
Firebox, water space	F.-3.74, S.-3.1, B.-3.66 in.
Tubes, number and outside diameter	261—2.17 in.
Tubes, length	19 ft. 6 in.
Heating surface, tubes	2,863.5 sq. ft.
Heating surface, firebox	184.7 sq. ft.
Heating surface, total	3,048.2 sq. ft.
Grate area	45.7 sq. ft.
Smokestack, diameter	19.7 in.
Smokestack, height above rail	171 in.
Center of boiler above rail	111 in.

TENDER.

Tank	Water Bottom
Frame	Steel
Wheels, diameter	48.8 in.
Journals, diameter and length	5.5 × 9.85 in.
Water capacity	5,300 gals.

LONGITUDINAL VS. TRANSVERSE SHOPS.

After a thorough experience with both types, I have come to prefer the longitudinal shop for any location where the surroundings will permit its use. My principal reasons for this preference are as follows:

(1) The transverse requires between twenty-five and thirty per cent. more erecting floor area per locomotive under repairs, and about fifteen per cent. more machine shop area than the longitudinal shop. These figures are based on, and confirmed by, a comparison of ten well-known shops; five of each type.

(2) The longitudinal shop has greater flexibility as the number of engines under repairs can be varied according to their size and the spacing required, while in a transverse shop, the pits, drop tables or cranes, etc., cannot be lengthened out to fit larger power at a reasonable cost. For this reason many transverse shops have been entirely outgrown by the large modern power, and, if the articulated type of locomotives come into general use, most of the modern transverse shops will very soon be outgrown in the same manner. This is not true to the same extent of old longitudinal shops, nor is it at all probable with any of the recent shops of this type.

(3) The cost per square foot of area averages somewhat less for longitudinal than for transverse shops on account of the design of the building. The transverse shop generally requires large double doors for every pit, and the cost of the pits themselves is greater, besides some other less expensive features in favor of the longitudinal shops.

(4) Advocates of both types of shop claim that their preferred

operates in a vertical plane instead of horizontally, as is universal American practice, is placed on the back head, the rod from the valve being inside the boiler and passing through a stuffing box at this point. In connection with the valve gear it will be noticed that the valve chambers of the high-pressure cylinders are set outside the cylinders so as to give a direct drive from the return crank, while with the inside gears there is a difference of nearly 14 inches between the plane of the valve stem and that of the eccentric. This offset is provided by means of an extended trunnion on the link with a downwardly extending arm at the end. To prevent any springing at this point the links have liberal supports at three points.

The details of the cylinder castings are shown in one of the illustrations. The high-pressure cylinders with the piston valve chambers are in separate castings, which are bolted to the plate frames just ahead of the front driving wheels. The steam passage continued from the front by a bend of large radius to the center of the valve chamber, and the exhaust passages, which are, of course, separated from entering steam by air spaces, emerge just below it and are continued to the receiver by a short section of heavily lagged piping. The castings are made as light as possible and of the best grade of grey iron. All passages are made individual as far as possible and stayed by ribs to each other and the main casting.

The two low-pressure cylinders, together with the saddle and their steam chests and receiver are in one casting. They set between the frames which are widened at this point to permit the use of 25.2 in. diameter cylinders. The low-pressure valves are of bronze and of the plain unbalanced slide type. They have inclined seats and extend slightly over the top of the frames. The passages throughout are very large and give free movement to the steam. In order to provide clearance for the front truck, all the cylinders are slightly inclined.

The boiler is also shown in detail in one of the illustrations. It is of the straight top type with Belpaire firebox, the firebox being copper. All the stays in the water legs are of manganese bronze, while the crown and boiler stays are of Falls Hollow stay bolt iron. The barrel is made up of sheets about .79 in. in thickness, there being three rings. The front tube sheet, which is nearly 1 in. thick, is flanged and set into the front course sheet. It is braced above the flues by two horizontal plates about 14 in. wide and .63 in. thick.

The dome construction is somewhat unusual and consists of a lower section of 6 in. steel flanged to fit the boiler, and a hemispherical upper section of the same material. The two are joined by a flange, the arrangement being such that the upper sheet fits inside the flange on the lower section in the manner shown in the illustration. The dome is set 65 in. back of the tube sheet.

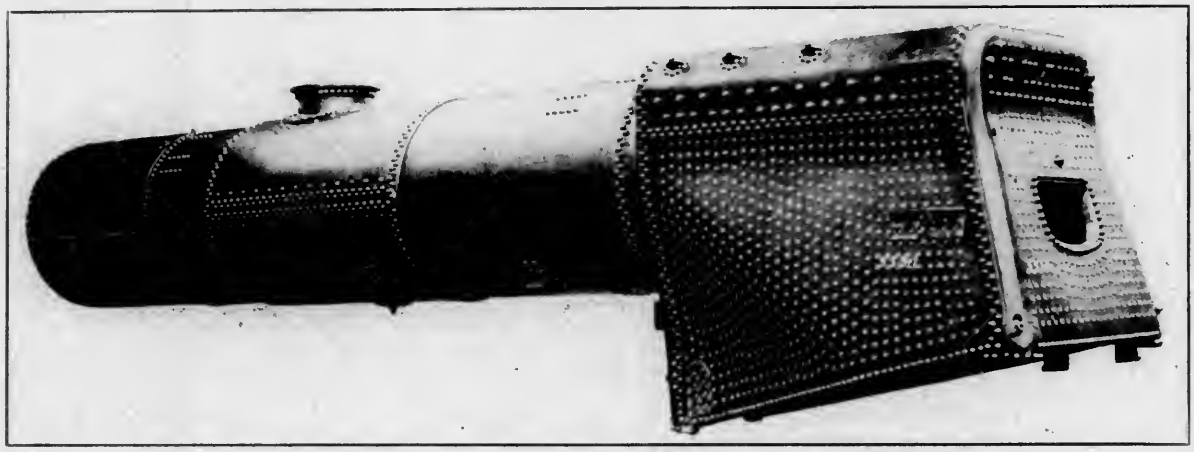
The boiler contains 261 tubes 2.165 in. in diameter, which are set at 2.84 in. centers. They have a drop of about two inches toward the firebox. The back tube sheet of copper is 1.18 in. thick where the tubes enter and is narrowed to .63 in. thick at the throat, where it is held by stays. The throat is 37.9 in. deep and the water space is 3.74 in. at the mud ring. The crown sheet has a slope of about 2 in. toward the rear and is made of copper .63 in. thick. It will be noted that the back head braces are all fitted with nuts for correct distribution of the stresses after the boiler is erected.

The grate has a very decided slope, the difference in level being 21.7 in. The door opening is of peculiar shape, shown in the illustration. It is 27.5 in. wide and 15.75 in. high. The back firebox sheet is dished at the door to permit the use of a door ring only 2.36 in. wide.

The method of setting the tubes is also shown in the illustration. The hole in the back sheet is taper and the tube is swaged down to enter and is rolled and beaded. The holes in the front sheet are straight, 2.24 in. in diameter and the tube is simply expanded and rolled.

The smoke-box is provided with a high exhaust pipe fitted with a variable exhaust nozzle. This device consists of a hollow cone fitted in the top of the exhaust pipe, the largest outside diameter of which is equal to the inside diameter of the tip of the nozzle. This cone is connected to the horizontal arm of a shaft which extends out of the side of the smoke-box, and is operated from the cab by means of a screw and hand wheel. By lowering or raising the cone, the amount of the exhaust opening is increased or diminished.

The blower nozzle, of bronze, is a hollow ring surrounding the exhaust nozzle and provided with a number of holes in its upper face. A sprinkling device is also provided in the smoke-box for extinguishing hot cinders. The smoke-stack is of cast iron, and is provided with a hood, by means of which the draft may be checked when the engine is standing in a station or drifting.

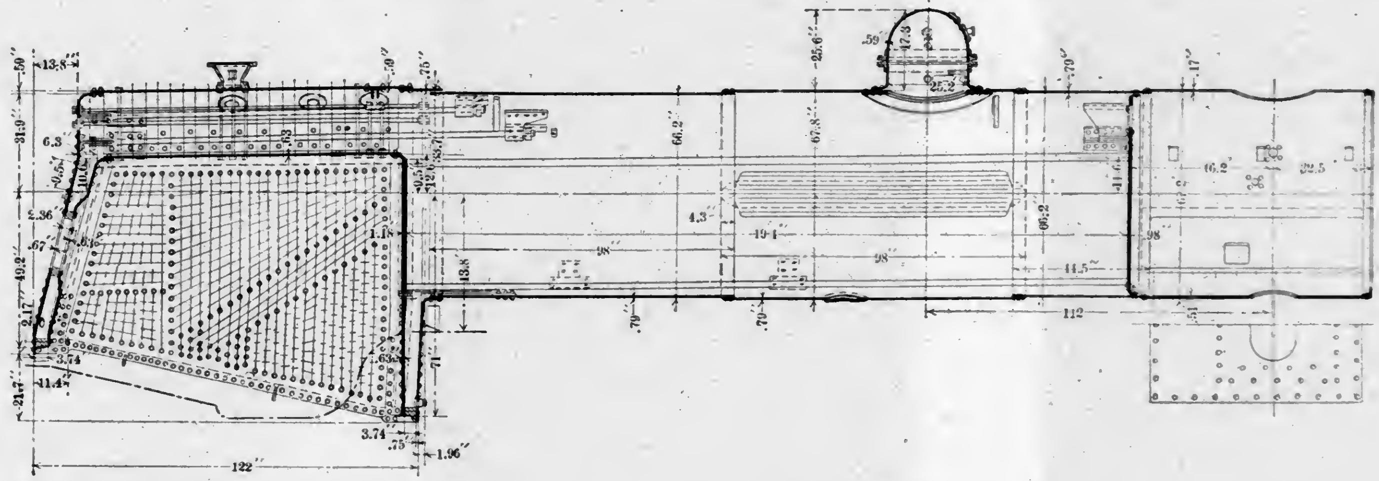


BOILER FOR THE DE GLEHN COMPOUND PACIFIC TYPE LOCOMOTIVE.

The frames are of steel plate in two sections, the main frames being 1.26 in. thick, and the rear section for the trailing truck being 1.18 in. thick. A good depth of plate is provided over the pedestals. They are very strongly tied together, the location and arrangement of the bracing being shown in the elevation and cross sections. The low-pressure guides and also the low-pressure link supports are bolted to the heavy steel box casting between the high-pressure cylinders. The outside guides and high-pressure link supports are bolted to cast steel guide yokes secured to the frames. All the axles are forged steel, the crank axle being a single forging. The driving boxes are also of forged steel.

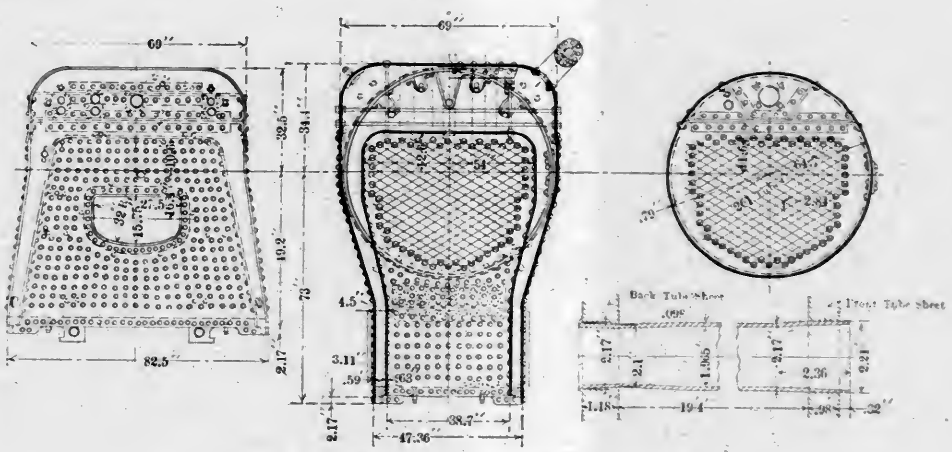
The three pairs of driving wheels are equalized together, the under-hung spring system being employed. Contrary to American practice in this type of engine, however, the trailing truck is not equalized with the driving wheels. It is of the side motion type with inside bearings, lateral motion being provided by 3.5[illegible] in. play between the boxes and pedestals on each side, and the load on the truck is utilized to bring it back to its central position.

The front engine truck is the Paris-Orleans standard design all the weight being transferred to it by means of two hemispherical side bearings seated in castings which can slide on the



cast steel center frame. The truck is brought back to its central position after leaving a curve by means of two transverse coil springs, one on either side of the center plate.

The tender tank is of the water bottom type and has a water capacity of 5,300 gallons. It is provided with three gauge cocks on the left side to show the level of the water in the tank. The tender frame consists of two steel plate side frames, placed outside of the wheels and strongly braced together. The tender is carried on six wheels and the weight is transmitted to the journal boxes through semi-elliptic springs over the top of each box, the two rear pairs of wheels being equalized together.



BOILER—DE GLEHN COMPOUND LOCOMOTIVE.

The general dimensions, weights and ratios are as follows:

GENERAL DATA.

Gauge	4 ft. 9 in.
Service	Passenger
Fuel	Coal
Tractive effort	24,940 lbs.
Weight in working order	195,000 lbs.
Weight on drivers	122,000 lbs.
Weight of engine and tender in working order	291,800 lbs.
Wheel base, driving	12 ft. 9.54 in.
Wheel base, total	34 ft. 5.4 in.
Wheel base, engine and tender	58 ft. 5.2 in.

RATIOS.

Weight on drivers ÷ tractive effort	4.9
Total weight ÷ tractive effort	7.8
Tractive effort × diam. drivers ÷ heating surface	597.0
Total heating surface ÷ grate area	66.5
Firebox heating surface ÷ total heating surface, per cent	6.1
Weight on drivers ÷ total heating surface	40.2
Total weight ÷ total heating surface	64.1
Volume equiv. simple cylinders, cu. ft	8.0
Total heating surface ÷ vol. cylinders	380.0
Grate area ÷ vol. cylinders	5.7

CYLINDERS.

Kind	DeGlehn Comp.
Diameter and stroke	15.35 and 25.2 × 25.6 in.

VALVES.

Kind	H. P.-Piston, L. P.-Slide
Greatest travel	H. P.-5.25 in., L. P.-5.7 in
Outside lap	H. P.-1.06, L. P.-1.06 in.
Inside lap	H. P.-.118, L. P.-.197 in.

WHEELS.

Driving, diameter over tires	72.8 in.
Driving journals, diameter and length	8.65 × 9.45 in.
Engine truck wheels, diameter	37.8 in.
Engine truck, journals	5.9 × 9.85 in.
Trailing truck wheels, diameter	45.2 in.
Trailing truck, journals	7.1 × 11.8 in.

BOILER.

Style	Belpaire
Working pressure	227.6 lbs.
Outside diameter of first ring	66.2 in.
Firebox, length	112 in.
Firebox, width	F. 38.8, B.-74 in.
Firebox plates, thickness	.63 in.
Firebox, water space	F.-3.74, S. 3.1, B. 3.66 in.
Tubes, number and outside diameter	201 2.17 in.
Tubes, length	19 ft. 6 in.
Heating surface, tubes	2,863.5 sq. ft.
Heating surface, firebox	184.7 sq. ft.
Heating surface, total	3,048.2 sq. ft.
Grate area	45.7 sq. ft.
Smokestack, diameter	19.7 in.
Smokestack, height above rail	171 in.
Center of boiler above rail	111 in.

TENDER.

Tank	Water Bottom
Frame	Steel
Wheels, diameter	48.8 in.
Journals, diameter and length	5.5 × 9.85 in.
Water capacity	5,300 gals.

LONGITUDINAL VS. TRANSVERSE SHOPS.

After a thorough experience with both types, I have come to prefer the longitudinal shop for any location where the surroundings will permit its use. My principal reasons for this preference are as follows:

(1) The transverse requires between twenty-five and thirty per cent. more erecting floor area per locomotive under repairs, and about fifteen per cent. more machine shop area than the longitudinal shop. These figures are based on, and confirmed by, a comparison of ten well known shops; five of each type.

(2) The longitudinal shop has greater flexibility as the number of engines under repairs can be varied according to their size and the spacing required, while in a transverse shop, the pits, drop tables or cranes, etc., cannot be lengthened out to fit larger power at a reasonable cost. For this reason many transverse shops have been entirely outgrown by the large modern power, and, if the articulated type of locomotives come into general use, most of the modern transverse shops will very soon be outgrown in the same manner. This is not true to the same extent of old longitudinal shops, nor is it at all probable with any of the recent shops of this type.

(3) The cost per square foot of area averages somewhat less for longitudinal than for transverse shops on account of the design of the building. The transverse shop generally requires large double doors for every pit, and the cost of the pits themselves is greater, besides some other less expensive features in favor of the longitudinal shops.

(4) Advocates of both types of shop claim that their preferred

arrangement best facilitates the supervision of the locomotive repairs, but I believe that whatever difference there is in this respect is in favor of the longitudinal shop, provided the organizations are equally good in each case. With either type of shop, a foreman or master mechanic cannot personally supervise the work from his office, but must circulate around among the locomotives and make frequent personal inspections of the work. As a rule, I believe that a gang foreman can personally supervise the work on a larger number of locomotives in a longitudinal shop than is possible in a transverse shop. This opinion is based on considerable experience with both types of shops, which leads me to claim that the longitudinal shop is the best for supervision.

(5) With very few exceptions, the output of locomotives per month is greater for longitudinal than for transverse shops. A committee on railroad shops reported to the American Master Mechanics' Association, 1905, giving the monthly output on a ten-hour day basis, as follows:

Eight longitudinal shops, engines per pit...... 1.61
Eight transverse shops, engines per pit........ 1.27

This shows the output of the longitudinal shops about twenty-five per cent. greater than that of the transverse shops, and these results are confirmed by my observations of other shops than those covered by the committee's report.

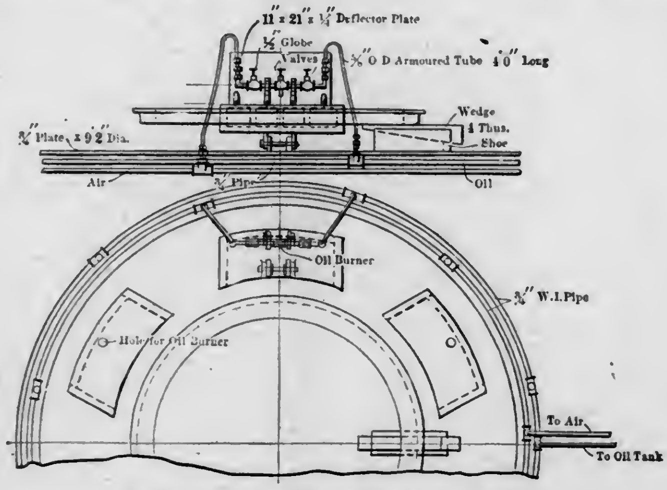
I might also mention the transfer table generally used with the transverse shops and some other features of less importance, but believe that the arguments above presented will be difficult to offset and quite sufficient to warrant my preference for the longitudinal type of locomotive repair shop.—*M. K. Barnum before the Canadian Railway Club.*

TIRE HEATER.

CANADIAN PACIFIC RAILWAY.

The Canadian Pacific Railway has recently introduced a new type of tire heater at its Angus works, which has been found to be far more efficient than the former method of using gasoline and perforated rings of pipe, which slip over the tires. The new heater uses crude oil and consists of six small portable furnaces which are placed on a cast iron plate, as shown in the illustrations. These furnaces consist of cast iron boxes, each supported on four cast iron wheels $3\frac{1}{2}$ in. in diameter. The inside of the box is lined with fire brick $1\frac{1}{2}$ in. thick. A deflector plate is attached to the top of each furnace. The crude oil and compressed air are conducted from the $\frac{3}{4}$-in. pipes, which surround the base of the device, to the burners through $\frac{5}{8}$-in. armored tubes, as shown. It is possible to adjust these portable furnaces so as to produce perfect combustion and to direct the flame on the tire to the best advantage, heating it up much more quickly than by the former methods. A jib crane extends over the heater and the center is lowered into the tire when it has been heated sufficiently. Two of these heaters have been placed in commission and are giving splendid results. We are indebted for information to A. W. Horsey, mechanical engineer.

CRUDE OIL TIRE HEATER AT THE ANGUS SHOPS, CANADIAN PACIFIC RAILWAY.



GENERAL ARRANGEMENT OF TIRE HEATER.

THE FASTEST MOTOR BOAT.—On August 4, the motor boat "Dixie II." made a series of four trial runs over the measured course of the New York Yacht Club in Hempstead Harbor, L. I., which is 1.1 nautical miles long. The boat ran twice with the tide and twice against it. Its average for the four trials was at the rate of 35.74 statute miles an hour, which is the fastest time ever made by a motor boat on officially timed tests, either in this country or abroad. The "Dixie II.," which won the international motor boat race at Huntington, on August 4, was designed by Clinton H. Crane, with engines by Crane & Whitman. It has a single propeller, driven by an eight-cylinder gasoline engine, and can make a trifle more than 800 revolutions per minute, with horse-power of slightly over 200.—*Railroad Age Gazette.*

THE FUTURE OF THE APPRENTICE.

By R. I. Graves.

Editor's Note: This paper was written by one of the apprentices of the Chicago & Northwestern Railway. The circumstances under which it was prepared may best be presented by quoting from the remarks of H. T. Bentley, assistant superintendent motive power and machinery of that road, in speaking on the apprenticeship question at the recent meeting of the Master Mechanics' Association:

"Unfortunately we have not such a good scheme of teaching the apprentices on the Chicago & Northwestern as is set forth by the committee; but with 45 apprentices we have two apprentice instructors who follow the young men up and give them every opportunity of becoming proficient in the work they are undertaking, and I think it has had a good effect. We give a certificate or diploma as soon as the young man is out of his time which shows where he served his time and what course he has gone through. About 12 months ago the apprentices themselves organized an apprentice club; they have held 14 meetings and the average attendance at these meetings was 22. To show the scope of the papers and discussions I will name a few of them. The first was, 'The Future of the Apprentice,' and it was one of the best written papers I ever came across. Others were 'The D Slide Valve,' 'Stephenson Link Motion,' 'Valve Setting,' 'The Air Brake,' 'Injectors,' 'Lubricators,' and 'Theory of Combustion.' All the 45 are members of the apprentice club and the officials endeavor to encourage the young men by their presence and to help them by furnishing information they are not able to obtain in any other way."

The future of an apprentice depends upon himself. Whether the future is to be bright and successful, or whether it is to be a dull, common-place existence and a failure, is for each of us to determine. In every case it is up to the man. In this age of hustle and progress, where momentous undertakings and large responsibilities are everywhere in evidence, and where men are constantly departing from the arena of activities because of ill health, old age, and other very good reasons, there comes a cry for trained men, competent men, and reliable men. This "cry" is a demand for men who know their business, for men who are specialists in their line, for men who have been through the mill of practical experience, and who thoroughly understand the work they are called upon to superintend.

To answer this "cry," and to provide for the time when the present officials shall have retired from service, there has been instituted in the shops the apprentice system. We all know what this system is, but do we all realize what it means? We know that when our time is served that we are ranked as machinists and that we are entitled to machinists' wages, but is that all? Is our trade to be the end of our ambition, and are we always to be machinists?

To this point the sailing is quite clear, but as to the future, from here the course seems to be somewhat hazy and uncertain. It is plain that the apprentice becomes a machinist; that when the preliminary training is completed, the young man is well grounded in the fundamentals, that he can do a job on this machine, or that machine, and that he understands mechanical work. It is at this stage that many men stop. They become accustomed to a certain line of work, such as running a drill press, working on rods or a dozen other jobs, and they are content to remain machinists. But there are some men who are not satisfied to remain as machinists, and they refuse to remain stationary. They study, they work faithfully, and in time become foremen, then they go on to master mechanic, and so on they climb to the top.

Now, the men at the top do not want you to be a machinist all your life. They did not give you the opportunity of learning the trade that you might earn good wages and have easy hours. They want you to become good workmen; to do your work well; they want men whose work they can depend upon, and they hope that out of the many apprentices there will be some who will excel, who will develop qualities that will fit them for future officers. They know that all human beings are not the same; that many are shiftless and indifferent, while others are industrious and interested in their work. Of this latter class, they have figured to choose men to fill positions that are being vacated from time to time. The company needs a foreman to-day and a master mechanic to-morrow, and to supply its need, it looks first to its own men. A good man is wanted; he is in demand, and if you are the right man, you will get the position. Thus, you see, the object of the apprentice system. It is a necessity for the future welfare of the company, and being a necessity, it makes the future bright for every apprentice.

The future is indeed bright and promising for the apprentice; there are more chances for him to succeed to-day than ever before. Take a glance at the big men in the railway world and examine their careers. You will find that their records began at the bottom, and that they fought their way on and upward. You will see that the position they hold to-day is the result of hard and faithful application to work and duty.

Let me quote you a few words that Mr. George A. Post, president of the Standard Coupler Company, said about some of the many men who have come up from the ranks: "That masterful personality, Deems, looks now as though he always wielded a scepter, but he didn't. It was not long ago that he wore a 'jumper,' looking after a roundhouse out West. But inside that 'jumper' was a natural-born jumper, and he jumped and he landed, too.

"Facing the blizzards of the Northwest, as he trod the icy roofs of the freight cars in winter, there was once a broad-shouldered, sturdy brakeman, named Underwood. He is not a brakeman now; he's president of the Erie.

"Throwing wood on a locomotive tender and working as a section hand, are both mighty good exercise, but there must be something besides muscle about a young fellow who began his career by doing these things, and who fought his way up to be second in command of the New York Central Lines. Brown accomplished that.

"Outfitted with an ordinary common school education, plus horse sense, pluck and an extra ladle full of gray matter, Truesdale, of the Lackawanna, has winged his flight from a hard-bottomed chair as a clerk to the sumptuous quarters of a railway president."

And there are many, many other cases that might be cited, showing what grit and determination can accomplish. I have quoted these incidences of success that we may see what has been done, and to show us what we have to strive for. If such men have come from the shops, and from the office in the past, they are certainly going to continue to come from these places in the present and in the future.

There are many prizes to be had for the working and the future is full of rewards for the apprentice, if he is the right man. One man has said that success is inevitable to those who boost themselves by their own boosting strength of will and accumulated knowledge. The fellows who go into the shop day after day, wishing that their time was served, wishing that they were drawing machinists' wages, and trying to do as little work as possible, are not going to amount to much. But there are other fellows who are different, and to quote from Mr. Post again: "They have sand, and are not afraid of doing a big day's work; they are not afraid they will do more than some other fellow who gets the same or more pay. They keep their eyes and ears open. They seek instead of shirk responsibility; they look upon their employer as their friend, and not as an enemy." These are the fellows who make good machinists and good officers. To them the future holds many rewards. Mr. Angus Sinclair has said: "A good hand at any occupation, no matter how humble it may be, recommends himself for advancement. The good mechanic, the good car repairer, the skilful foreman, the first-class engineer; the quick, accurate telegraph operator; the pushing, clear-headed track workman; the flagman who protects his train, and the machinist who does his work well, are the men who will be officials a generation hence."

In every new subject that seems uncertain and difficult to us,

arrangement best facilitates the supervision of the locomotive repairs, but I believe that whatever difference there is in this respect is in favor of the longitudinal shop, provided the organizations are equally good in each case. With either type of shop, a foreman or master mechanic cannot personally supervise the work from his office, but must circulate around among the locomotives and make frequent personal inspections of the work. As a rule, I believe that a gang foreman can personally supervise the work on a larger number of locomotives in a longitudinal shop than is possible in a transverse shop. This opinion is based on considerable experience with both types of shops, which leads me to claim that the longitudinal shop is the best for supervision.

(5) With very few exceptions, the output of locomotives per month is greater for longitudinal than for transverse shops. A committee on railroad shops reported to the American Master Mechanics' Association, 1905, giving the monthly output on a ten-hour day basis, as follows:

Eight longitudinal shops, engines per pit...... 1.61
Eight transverse shops, engines per pit........ 1.27

This shows the output of the longitudinal shops about twenty-five per cent. greater than that of the transverse shops, and these results are confirmed by my observations of other shops than those covered by the committee's report.

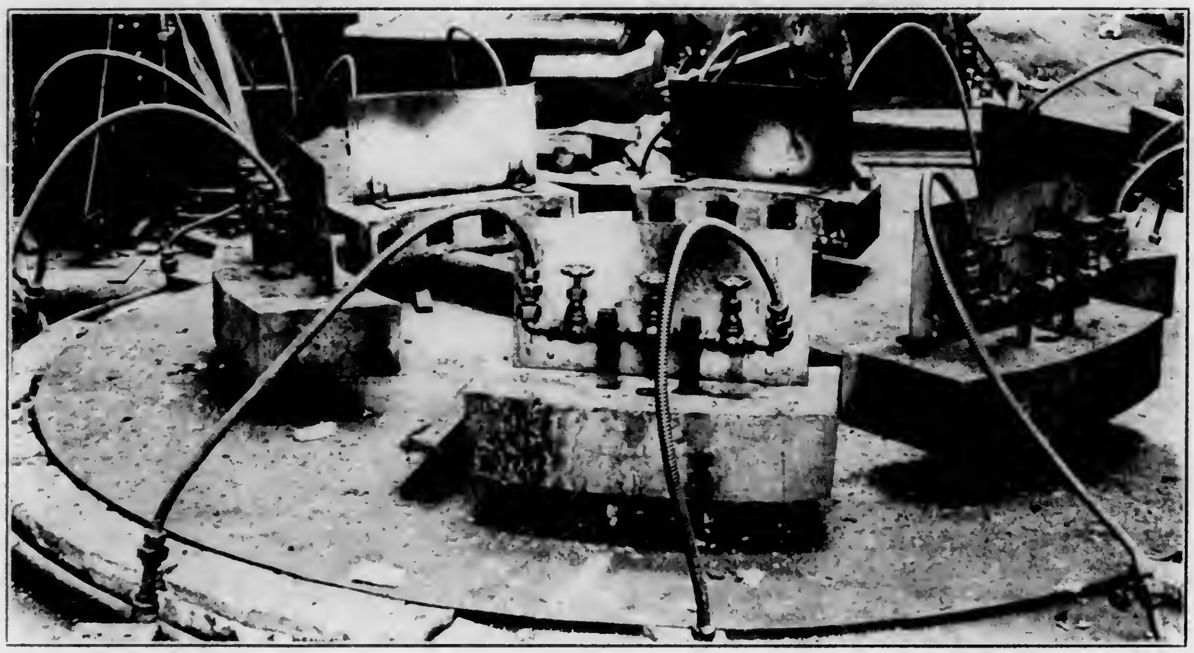
I might also mention the transfer table generally used with the transverse shops and some other features of less importance, but believe that the arguments above presented will be difficult to offset and quite sufficient to warrant my preference for the longitudinal type of locomotive repair shop.—*M. K. Barnum before the Canadian Railway Club.*

TIRE HEATER.

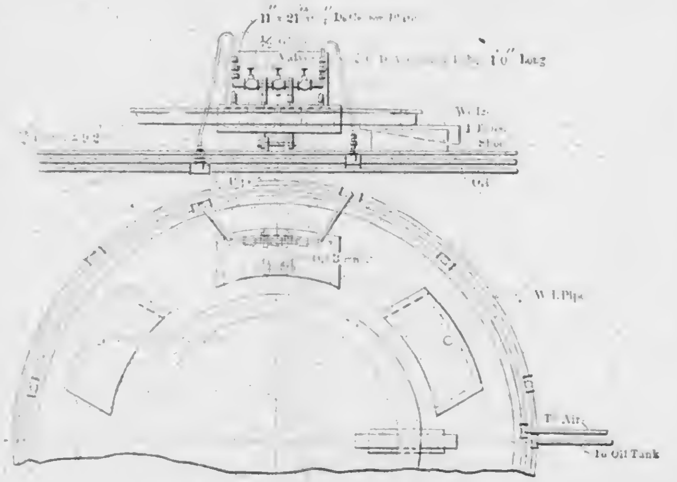
CANADIAN PACIFIC RAILWAY.

The Canadian Pacific Railway has recently introduced a new type of tire heater at its Angus works, which has been found to be far more efficient than the former method of using gasoline and perforated rings of pipe, which slip over the tires.

The new heater uses crude oil and consists of six small portable furnaces which are placed on a cast iron plate, as shown in the illustrations. These furnaces consist of cast iron boxes, each supported on four cast iron wheels $3\frac{1}{2}$ in. in diameter. The inside of the box is lined with fire brick $1\frac{1}{2}$ in. thick. A deflector plate is attached to the top of each furnace. The crude oil and compressed air are conducted from the $\frac{3}{4}$-in. pipes, which surround the base of the device, to the burners through $\frac{5}{8}$ in. armored tubes, as shown. It is possible to adjust these portable furnaces so as to produce perfect combustion and to direct the flame on the tire to the best advantage, heating it up much more quickly than by the former methods. A jib crane extends over the heater and the center is lowered into the tire when it has been heated sufficiently. Two of these heaters have been placed in commission and are giving splendid results. We are indebted for information to A. W. Horsey, mechanical engineer.



CRUDE OIL TIRE HEATER AT THE ANGUS SHOPS, CANADIAN PACIFIC RAILWAY.



GENERAL ARRANGEMENT OF TIRE HEATER.

THE FASTEST MOTOR BOAT.—On August 4, the motor boat "Dixie II." made a series of four trial runs over the measured course of the New York Yacht Club in Hempstead Harbor, L. I., which is 1.1 nautical miles long. The boat ran twice with the tide and twice against it. Its average for the four trials was at the rate of 35.74 statute miles an hour, which is the fastest time ever made by a motor boat on officially timed tests, either in this country or abroad. The "Dixie II.," which won the international motor boat race at Huntington, on August 4, was designed by Clinton H. Crane, with engines by Crane & Whitman. It has a single propeller, driven by an eight-cylinder gasoline engine, and can make a trifle more than 800 revolutions per minute, with horse-power of slightly over 200.—*Railroad Age Gazette.*

THE FUTURE OF THE APPRENTICE.

By R. I. GRAVES.

Editor's Note: This paper was written by one of the apprentices of the Chicago & Northwestern Railway. The circumstances under which it was prepared may best be presented by quoting from the remarks of H. T. Bentley, assistant superintendent motive power and machinery of that road, in speaking on the apprenticeship question at the recent meeting of the Master Mechanics' Association:

"Unfortunately we have not such a good scheme of teaching the apprentices on the Chicago & Northwestern as is set forth by the committee; but with 45 apprentices we have two apprentice instructors who follow the young men up and give them every opportunity of becoming proficient in the work they are undertaking, and I think it has had a good effect. We give a certificate or diploma as soon as the young man is out of his time which shows where he served his time and what course he has gone through. About 12 months ago the apprentices themselves organized an apprentice club; they have held 11 meetings and the average attendance at these meetings was 22. To show the scope of the papers and discussions I will name a few of them. The first was, 'The Future of the Apprentice,' and it was one of the best written papers I ever came across. Others were 'The D Slide Valve,' 'Stephenson Link Motion,' 'Valve Setting,' 'The Air Brake,' 'Injectors,' 'Lubricators,' and 'Theory of Combustion.' All the 45 are members of the apprentice club and the officials endeavor to encourage the young men by their presence and to help them by furnishing information they are not able to obtain in any other way."

The future of an apprentice depends upon himself. Whether the future is to be bright and successful, or whether it is to be a dull, common place existence and a failure, is for each of us to determine. In every case it is up to the man. In this age of hustle and progress, where momentous undertakings and large responsibilities are everywhere in evidence, and where men are constantly departing from the arena of activities because of ill health, old age, and other very good reasons, there comes a cry for trained men, competent men, and reliable men. This "cry" is a demand for men who know their business, for men who are specialists in their line, for men who have been through the mill of practical experience, and who thoroughly understand the work they are called upon to superintend.

To answer this "cry," and to provide for the time when the present officials shall have retired from service, there has been instituted in the shops the apprentice system. We all know what this system is, but do we all realize what it means? We know that when our time is served that we are ranked as machinists and that we are entitled to machinists' wages, but is that all? Is our trade to be the end of our ambition, and are we always to be machinists?

To this point the sailing is quite clear, but as to the future, from here the course seems to be somewhat hazy and uncertain. It is plain that the apprentice becomes a machinist; that when the preliminary training is completed, the young man is well grounded in the fundamentals, that he can do a job on this machine, or that machine, and that he understands mechanical work. It is at this stage that many men stop. They become accustomed to a certain line of work, such as running a drill press, working on rods or a dozen other jobs, and they are content to remain machinists. But there are some men who are not satisfied to remain as machinists, and they refuse to remain stationary. They study, they work faithfully, and in time become foremen, then they go on to master mechanic, and so on they climb to the top.

Now, the men at the top do not want you to be a machinist all your life. They did not give you the opportunity of learning the trade that you might earn good wages and have easy hours. They want you to become good workmen; to do your work well; they want men whose work they can depend upon, and they hope that out of the many apprentices there will be some who will excel, who will develop qualities that will fit them for future officers. They know that all human beings are not the same; that many are shiftless and indifferent, while others are industrious and interested in their work. Of this latter class, they have figured to choose men to fill positions that are being vacated from time to time. The company needs a foreman to-day and a master mechanic to-morrow, and to supply its need, it looks first to its own men. A good man is wanted; he is in demand, and if you are the right man, you will get the position. Thus, you see, the object of the apprentice system. It is a necessity for the future welfare of the company, and being a necessity, it makes the future bright for every apprentice.

The future is indeed bright and promising for the apprentice, there are more chances for him to succeed to-day than ever before. Take a glance at the big men in the railway world and examine their careers. You will find that their records began at the bottom, and that they fought their way up and onward. You will see that the position they hold to-day is the result of hard and faithful application to work and duty.

Let me quote you a few words that Mr. George A. Post, president of the Standard Coupler Company, said about some of the many men who have come up from the ranks: "That masterful personality, Deems, looks now as though he always wielded a scepter, but he didn't. It was not long ago that he was a 'jumper,' looking after a roundhouse out West. But [illegible] that 'jumper' was a natural-born jumper, and he jumped and he landed, too.

"Facing the blizzards of the Northwest, as he trod the icy roofs of the freight cars in winter, there was once a broad-shouldered, sturdy brakeman, named Underwood. He is not a brakeman now; he's president of the Erie.

"Throwing wood on a locomotive tender and working as a section hand, are both mighty good exercise, but there must be something besides muscle about a young fellow who began his career by doing these things, and who fought his way up to be second in command of the New York Central Lines. Brown accomplished that.

"Outfitted with an ordinary common school education, his horse sense, pluck and [illegible] full of gray matter, Truesdale, of the Lackawanna, has winged his flight from a cane-bottomed chair as a clerk to the sumptuous quarters of a railway president."

And there are many, many other cases that might be cited, showing what grit and determination can accomplish. I have quoted these incidences of success that we may see what has been done, and to show us what we have to strive for. If such men have come from the shops, and from the offices in the past, they are certainly going to continue to come from these places in the present and in the future.

There are many prizes to be had for the working and the future is full of rewards for the apprentice, if he is the right man. One man has said that success is inevitable to those who boost themselves by their own boosting strength of will and accumulated knowledge. The fellows who go into the shop day after day, wishing that their time was served, wishing that they were drawing machinists' wages, and trying to do as little work as possible, are not going to amount to much. But there are other fellows who are different, and to quote from Mr. Post again: "They have sand, and are not afraid of doing a big day's work; they are not afraid they will do more than some other fellow who gets the same or more pay. They keep their eyes and ears open. They seek instead of shirk responsibility; they look upon their employer as their friend, and not as an enemy." These are the fellows who make good machinists and good officers. To them the future holds many rewards. Mr. Angus Sinclair has said: "A good hand at any occupation, no matter how humble it may be, recommends himself for advancement. The good mechanic, the good car repairer, the skilful foreman, the first-class engineer; the quick, accurate telegraph operator; the pushing, clear-headed track workman; the flagman who protects his train, and the machinist who does his work well, are the men who will be officials a generation hence."

In every new subject that seems uncertain and difficult to us,

there is nothing that makes it more clear, more real and more understandable than illustrations. Oftentimes when we have a job to do that is unfamiliar to us, we look around for something similar to it. If we can find a problem that was done like ours, then, by comparison, we can often do ours more easily. And so in this subject, "The Future of the Apprentice," if we look at the lives of officials, and examine their records, and see how they began their careers, and how they reached their present positions, we can get a better idea of how to accomplish our purpose.

In the Biographical Dictionary of Railway Officials, we find hundreds of men whose lives should serve as thrilling inspirations to the ambitious apprentice, and if, at any time, you feel blue and your ambition lacks enthusiasm, I would suggest that you get hold of this book and read what other railroad men have done. Here is one case which is briefly described: "Entered service of ——— R. R. as office boy, apprentice, machinist, worked in drawing office, chief draftsman, mechanical engineer, shop foreman, master mechanic, division superintendent, general superintendent, general manager, president."

Before concluding, there is one subject that I want to say a few words about, which, to my mind, is a most important essential for the *future of the apprentice.* Too much stress cannot be placed upon the education for a successful career. Education, fellows, is accumulated knowledge, a collection of facts. We cannot rise without knowledge, and definite knowledge gotten by experience is a necessity. If our collection of facts is small, we must increase it, and there are many ways to do this. There's the evening school, the correspondence school, the libraries, and our fellow workmen. And then, as a step, there is this society. As our constitution says, it is for the purpose of scientific investigation along railway lines. These bi-monthly meetings afford a means for study of the subject to be presented, an opportunity to express ourselves on our feet, to discuss the question, to exchange ideas for others, to correct ourselves if in the wrong, and to help the other fellow.

In concluding, allow me to say that diligent application, persistent plugging, a ceaseless hunt for knowledge, and straight living with grit and a big bump of common sense, will do wonders to brighten the *future of the apprentice.*

J. J. Hill's Rule for Success.—My rule for success is untiring application, loyalty to one's employer, which is loyalty to one's self, the "doing the best you can" in every task that faces you; practically, initiative and industry. I am not one, either, who does not believe in a college education for a young man. No man is injured by knowing too much, so long as he knows how to apply that knowledge in a practical way. I am not, however, defending the "intelligent theorist" who is too lazy or too visionary to push his ideas to practicality. But there is not a branch of modern business which does not need scientific knowledge. Why, railroading to-day is a science. So, sooner or later, all knowledge comes into play. But the workingman who does not hold a college degree has, if he has properly applied himself, a practical education that frequently enables him to advance all the faster. Above everything else, however, a man's determination, or his lack of it, to apply what he knows in his way may mean to him just the difference between ultimate success and failure. He need not worry about the opportunities. They are more immeasurably numerous than ever before in our history. And don't forget that opportunities for the man in the ranks, no matter how humble his position nor how poor his circumstances, are greater to-day than ever before.—*From an interview with a reporter of the New York Herald.*

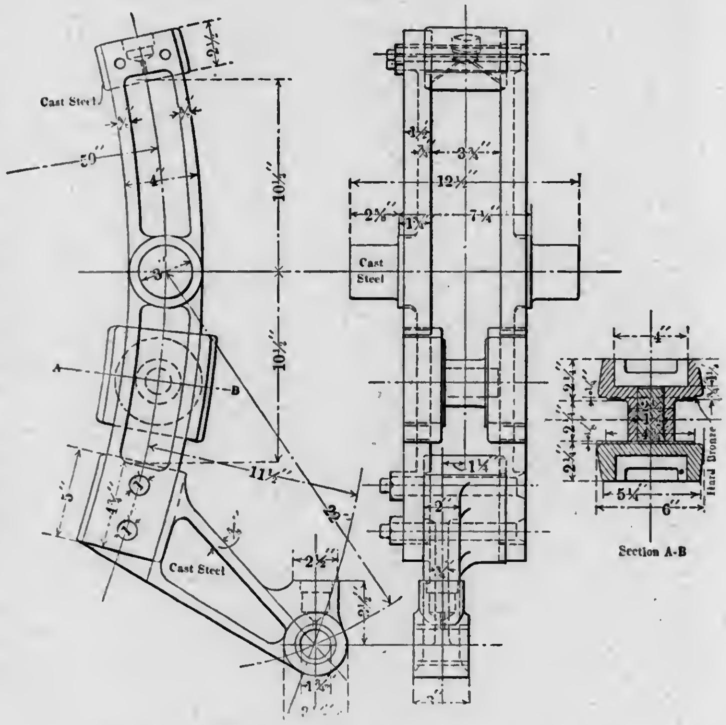
Panama Canal Excavation.—The total excavation for July was 3,168,640 cu. yds., against 3,056,976 cu. yds. for June, 2,703,923 cu. yds. for May and 1,077,498 cu. yds. for July a year ago. The average daily output for July, 1908, was 121,494 cu. yds., against 41,442 cu. yds. in July, 1907. In July of this year 1,874,173 cu. yds. of material were removed by steam shovels.

A SIMPLE DESIGN OF LINK AND LINK BLOCK.

The accompanying illustration shows a link and link block forming part of a Walschaert valve gear which was designed and recently applied by the Baldwin Locomotive Works to a Mikado type locomotive for the Kentucky and Tennessee Railway.

The link proper is built of four steel castings—two side plates and two filling pieces. Each side plate is cast in one piece with its corresponding trunnion and the lower filling piece is provided with an arm to which the eccentric rod is attached.

The link block is of hard bronze and is made in two pieces. It is guided in the link by projecting lips, which bear against



LINK AND LINK BLOCK FOR WALSCHAERT VALVE GEAR.

the edges of the side plates. The two sections of the block are held together by means of lugs, which are circular in section and fit one within the other. The larger and outside lug thus constitutes a pin for connection to the radius rod. The latter passes between the side plates and may be suspended either in front of or behind the link as preferred.

This link is supported by a bearing which is made in one piece and is assembled, with the radius rod, in this bearing. This makes a very simple arrangement with a minimum number of parts and amount of fitting. Application has been made for patents covering the special features of this link and block.

SUPERHEATING.

The following recommendations, as to the operation and maintenance of superheater engines, were made by the committee on superheating in its report at the recent meeting of The Traveling Engineers' Association.

In the operation of the superheaters the following suggestions should be carried out:

(a) When working steam, open throttle valve fully and regulate with cut-off.

(b) Keep water level in boiler as low as in saturated steam engines.

(c) Ascertain that dampers (where equipped) in smoke box are working properly, also that the small steam cylinder actuating these dampers is not leaking through stuffing box.

(d) Be sure that oil is carried from lubricator to each end of valve and also to cylinder.

(e) Any leaky steam joints at cylinders or valves should be tightened, and if connections or joints of superheater proper should be found leaking, report at once at end of run.

The work of maintaining and taking care of the superheater in the roundhouse is enumerated in the following:

(a) Keep all steam joints and connections of superheater, as well as cylinders and valves, tight.

(b) Piston and valve rings should have a close fit to cylinder walls and valve-bushings respectively.

(c) Clean or blow out large smoke flues whenever necessary. The more attention paid to this work, the more economy will be attained with the engine.

(d) The ends of the large smoke flues which originally were screwed in the fire-box flue sheet and have given trouble by leaking, should be rolled and expanded.

(e) In renewing tubes of superheater elements, use only seamless cold drawn steel tubing. See that they are put in correct length, otherwise, due to contraction and expansion, the connections in the U-bent castings will work loose and leak or tubes will split.

(f) The ends of the superheater elements nearest to the fire-box are supported by lugs or legs of the U-bent castings. Due to the expansion and contraction of the elements, these lugs ride or chafe the bottom of the large smoke flues. Ascertain if this riding or chafing has weakened the large tube. If so, renew the tube.

(g) Pay attention to the dampers, their lever connections and the small steam cylinder. Pack the latter whenever necessary, as any leakage will be detrimental to operating the dampers. See that all hinges of dampers, also the lever connections, are in good working order.

(h) The lubricator should be tested whenever necessary.

(i) Injectors must be connected with saturated steam. They will not work properly with superheated steam.

ROUNDHOUSE WORK REPORTS.

On page 191 of the May issue a division foreman directed attention to the necessity of improved methods of handling roundhouse work reports.

G. A. Miller, superintendent of motive power and machinery of the Florida East Coast Railway, has sent in the form shown in Fig. 1, which is used on that road. The engineer fills out this form in triplicate; the original copy he sends to the office of the superintendent of motive power and machinery and the duplicate and triplicate copies he gives to the roundhouse foreman. The roundhouse foreman personally assigns the different items of work to the men and keeps the work report on his desk until the work is completed, as it may be necessary for several men to refer to it and sign it. The men sign the triplicate report, which is retained by the roundhouse foreman. The foreman fills in the names of the workmen who perform the different jobs on the duplicate and forwards it to the superintendent of motive power and machinery. The note at the bottom of the duplicate reads as follows: "This copy to roundhouse foreman who will give proper credit to those who did the work, and send it to S. M. P. & M., St. Augustine." The note on the triplicate reads: "This copy for roundhouse foreman's reference and files."

Form 20   600 bks. 10 6 06 Record Co. 21997

FLORIDA EAST COAST RAILWAY.

ORIGINAL

.... Fla.,.......................190....

Report of work to be done on Eng. ....

Arr. on train.............at.............M.; Due to lve. on train.............at.............M.

.........................Engr.........................Hostler.

	WORK DONE BY	HRS.

NOTE: Report present work needed without reference to previous reports and each piece of work so that party doing same can sign against it. Send Original to S. M. P. & M., St. Augustine. Duplicate and Triplicate to Round House Man.

FIG. 1.—ENGINE WORK REPORT FORM, FLORIDA EAST COAST RY.

J. S. Sheafe, mechanical inspector of the Illinois Central, has directed attention to the form shown in Fig. 2, which is similar to one that has been used successfully on a western road. The engineer reports the defects, using a line for each item, so as to avoid confusion. The foreman may or may not assign the work, but in any case the workman signs the original work report, which remains upon a clip until the work is finished, or the engine goes out, when it is taken into the office for permanent record and is filed either under the engine number or the date. These reports can be handled many times without becoming illegible and the workmen take pains to keep the sheets in good condition. It is possible for the foreman to keep a close check on the work, if it is understood that the workmen are to sign the report as soon as each job is finished. Each engineer should use a separate sheet to avoid confusion.

THE COMPOUND LOCOMOTIVE.—There is nothing the matter with the compound locomotive; the only trouble with the use of these engines in the United States is that they require a greater attention, a greater detailed supervision of their finer mechanism, than is the case with simple engines which are cheaper to build, perhaps cheaper to maintain (though not on a performance-unit basis) and certainly less efficient in the use of power and in the haulage of loads. —*H. W. Jacobs in The Engineering Magazine.*

T-9-06-200 Bks 100 lvs.   Form No. 1443.

——— ——— Railroad Company.

Machinery Department.

REPORT OF WORK REQUIRED ON ENGINES. ________________ Shop.

Enginemen must carefully inspect their Engines after each trip and report all necessary repairs They will be held responsible for every defect not reported. No attention will be given to verbal report, or report not signed by Engineer. Employe making repairs will draw a line under each item of work completed, and sign his name opposite report.

DATE	ENGINE NUMBER AND INITIALS	REPAIRS REQUIRED	ENGINEER	REPAIRED BY

FIG. 2.—FORM IN SUCCESSFUL USE ON A WESTERN RAILWAY.

SUPERHEATED STEAM FOR LOCOMOTIVES.*

By Robert Garbe.†

Compounds and Superheating.—The use of highly superheated steam in a simple two-cylinder locomotive in its present state of development gives such a large increase in working capacity that the demands for increased hauling power and speed may in the immediate future be met together with increased economy, without having recourse to four-cylinder compounds, which are both complicated in construction and costly in maintenance. This, in the author's opinion, is one of the most essential advantages of superheated steam working in locomotive practice and has been taken into account in a large number—exceeding 1,000—of these engines in the Prussian State Railway service, all of which are of the simple two-cylinder form, without trailing axles, while the construction of the wet steam four-cylinder compounds has been almost entirely given up on that service. This example has not, however, been followed to the extent that, in the interest of simplicity, economy and safety in working, is to be desired. Many railway administrations for want of experience with superheated steam adhere to the costly and complicated four-cylinder wet-steam class, while others taking the first steps in superheating restrict it to moderate superheating in combination with the compound cylinder arrangement.

Both compound working with wet steam and high superheating have the same object, viz., the diminution or prevention of condensation losses in the cylinders, which in plain wet steam engines amounts to 35 per cent. and upwards. By compounding this may be reduced to 20 or 25 per cent., while with highly superheated steam at 600 or 660 degrees F. they may be entirely prevented, even in the simple two-cylinder locomotive. The question of initial superheat of about 100 degrees F. for preventing a deposit of water in the high pressure cylinder has been shown by Schmidt to be sufficient if the cut-off is not reduced below 50 per cent. of the stroke. This, however, entirely exhausts the extra heat so that the subsequent expansion in the low pressure cylinder is conducted under disadvantageous conditions. A notable steam saving by superheated compound as compared with superheated simple working can only be realized by avoiding low pressure cylinder condensation also, but this involves superheating to 570 degrees, and then it makes no difference whether the steam is expanded in one or two cylinders. With this degree of superheat, heavy steam admissions of 60 to 70 per cent. of the stroke, which are often required on grades, will raise the average temperature of the high pressure cylinder to such an extent as to cause lubrication troubles or even endanger its stability.

But even when highly superheated steam could be used on a compound locomotive the fuel economy as compared with a highly superheated simple engine would only be small and is not in any reasonable relation to the increased difficulties of construction, cost and maintenance. Above all, no notable increase in working capacity can be expected from it, as the most advantageous degree of steam admission is a fixed and invariable quantity for any particular average working demand and temperature. If this point is exceeded steam is wasted, and if it is reduced cylinder condensation results and the economy is reduced. Taking also into consideration the starting difficulties, the increased charge for boiler repairs, due to the objectionable high initial pressure of 200 pounds or more, and the increased capital and maintenance cost, its adoption can in no case be recommended merely on the ground of small fuel saving, which is only realizable under specially favorable conditions and involves the abandonment of the much greater advantages of the simple two-cylinder arrangement. The question of the number of cylinders is not included in the above considerations. The advantages of three and four cylinders on a locomotive are principally to be sought in the diminution of the so-called disturbing movements.

An undoubted advantage of the four-cylinder engine is to be found in the four crank arrangement, which by lowering the strain on the main axle bearings reduces the wear on the journals. Against this it must be borne in mind that the use of inside crank axles limits the possible length of the main journals.

When it is considered that the so-called disturbing motions give rise to close recurring and non-culminative powers, and that the equalizing of the reciprocating masses in two-cylinder engines must not be pushed too far, to avoid excessive variation in the axle load during the revolution of the wheel, and further that two crank engines run continuously and safely at speeds up to 75 miles an hour, the assumption appears to be justified that the use of more than two cylinders at the highest required speeds is not a question of greater safety, but only one of reducing wear on the bearing parts and smother running of the axle journals in their bearings, and not of the engine itself, or of quiet running on the rails so far as this depends upon the causes mentioned. It is a fact well established by practical trials that properly constructed two-cylinder engines in good working order run perfectly satisfactory at all speeds practically attainable. Further help along this direction has been obtained in the new superheated steam two-cylinder engines of the Prussian State Lines by the removal, on the author's advice, of the counterbalance on the driving wheels for the reciprocating parts and the adoption of a rigid tender coupling. In this way one of the much vaunted advantages of the four-cylinder engine, the repression of the vertical centrifugal force is obtained in a simple manner. The effect of the short connecting rod of the four-cylinder engine in increasing the vertical pressure on the cross-head, which acts alternately on the frame and the driving axles, is equally detrimental with the varying centrifugal forces of the counterbalance, and in this respect the simple two-cylinder engine with its long driving wheel base is decidedly superior to the multiple cylinder form.

This being so, the adoption in the plain two-cylinder engine of all available methods for preventing premature wear of the bearings is essentially to be recommended upon technical and economical grounds. These movements may be best attained by attention to the following simple conditions in combination with a sufficiently large rigid wheel base: Best materials for all reciprocating parts, so that they may be made as light as possible; enlargement of the journals and crank pins and use of three part axle bearings; proper stiffening of the frames; proper proportions of compression; improvement of the engine and tender couplings, by the use of a strong cross spring and reduction of the working pressure to 150 pounds.

Should the demand rise upon specially constructed lines for speeds of 70 miles an hour, on an average, with a maximum of 90 miles per hour, the necessity for the four-cylinder engine might be felt. This, however, could better be met by retaining the four-coupled eight-wheel form in combination with four equal-sized high-pressure cylinders and a long wheel base.

CONSTRUCTIVE DETAILS.

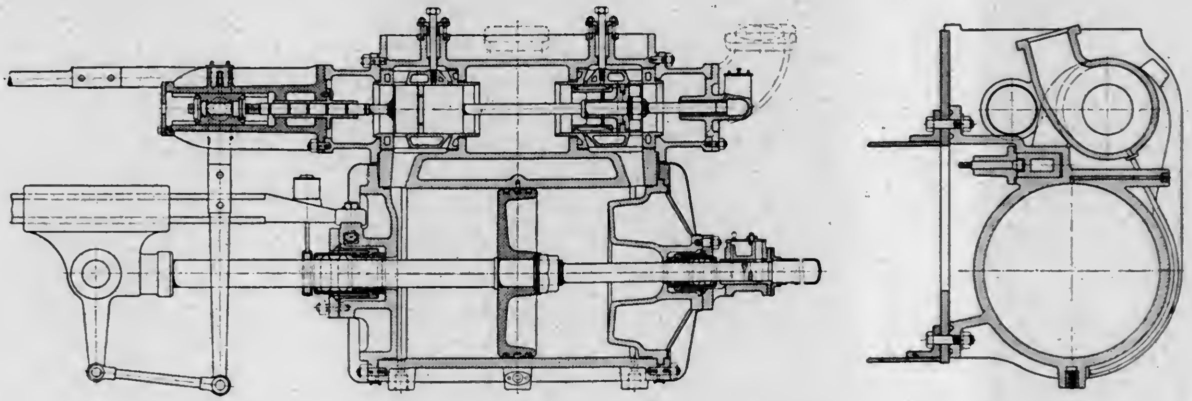
For the use of highly superheated steam it is essential that all parts of the engine with which it is brought in contact, such as cylinders, pistons, stuffing boxes, slide valves, etc., shall be constructed in such a manner as to meet the special properties of that medium. Although as in the case of other novelties, particularly in locomotive building, this was attended with considerable difficulty at first, such difficulty has now been overcome.

Cylinders and Pistons.—In the design of the hot steam cylinder particular care must be taken to avoid all sudden alterations of section likely to cause irregular expansion of the structure by heat, and the body of the cylindrical slide valve chest must be kept entirely separate from the cylinder in order that the latter may not be more highly heated in the parts nearest to the admission ports than in those nearest the exhaust ports.

After a long and troublesome series of experiments with a view of obtaining a tight working piston as nearly frictionless as possible, a simple modification of the well-known Swedish piston has been obtained (shown in Fig. 1), and has given extremely satisfactory results.

This success is due to the fact that the three light packing rings bear none of the weight of the body of the piston, their

*Abstract of a series of articles published in the *Engineer* (London). Continued from page 98, March issue of this journal.
† Privy Councilor, Prussian State Railways.



GENERAL ARRANGEMENT OF CYLINDERS AND VALVES FOR SUPERHEATED STEAM.

function being merely to form a steam-tight joint by their slight elasticity and the small pressure acting behind them jointly. Three rings are used in order that the middle one may never be subjected to back pressure. Each of the rings is perforated radially by six holes .118 in. in diameter, spaced at equal distances apart, and opening into a shallow groove turned into the outer surface, giving a series of passages from the front to the back of the ring. When, therefore, at the change of stroke the first or third ring is driven by compression out of contact with the cylinder, steam makes its way behind it through the small exposed passage and

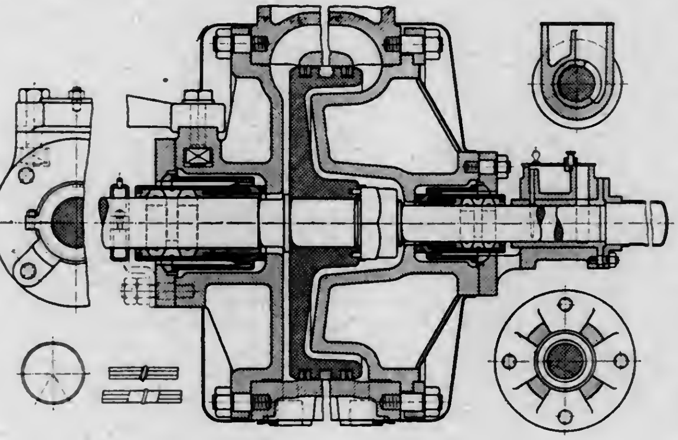


FIG. 1.—PISTON USED WITH SUPERHEATED STEAM.

presses it back, a too sudden restoration of the contact being prevented by the reflex action of part of the steam flowing back into the groove and cushioning the blow. Furthermore, a small amount of steam finds its way between the ends of the second and third rings and their seats on the piston, relieving the pressure sufficiently to insure merely a light contact with the side of the cylinder.

The piston body, cast of the highest quality of steel, is made as light as possible. Both the outer and inner edges of the ring seats are rounded, the former somewhat more than the latter, to facilitate distribution of the lubricating oil. The diameter is made about .118 in. less than that of the cylinder to prevent cutting during withdrawal, and also when, from wear in the stuffing-boxes, the piston is no longer perfectly central. Neither the body of the piston, the packing rings, nor the stuffing-boxes must at any time carry any part of the weight of the piston. The piston rod has a special guide in front, and is carried behind by the crosshead, so that the piston is kept nearly floating in the cylinder.

Stuffing-Boxes.—With hot steam the use of metallic packing with free lateral motion for the piston-rod is essential. A packing, which has been quite successful, is shown in detail in Fig. 1.

If the piston is kept centered as closely as possible by proper packing of the crosshead slipper, and timely renewal of the forward guide-bars, which measures are absolutely necessary for proper and regular working, the stuffing-box packings will run for years with extremely small wear in any of their parts.

Piston Valves.—In all hot steam engines piston valves should be used, the steam being admitted from the inside, giving a naturally balanced construction. This does away with the necessity of stuffing-boxes in the valve chamber, as the outer surfaces of the valve are only under the low pressure of the exhaust steam, which is absorbed when a sufficiently long channel or labyrinth packing is used. These valves are constructed in two principal forms.

1. Piston valves with solid rings, double admission and steam jacketed valve chest.
2. Piston valves with partly counterbalanced spring rings and slide cover under steam pressure.

The first of these forms (shown in Fig. 2) is that principally used by the Prussian State Lines, while the second is favored by most of the other railways using superheated steam.

In the first valve the rings are undivided, and are closely fitted by grinding to gauge, being, as is the slide rod, kept tight by labyrinth packing grooves alone. With this arrangement the valve can be readily moved by hand, whatever may be the steam pressure in the valve chamber, the resistance being so small that all the motion parts may be made considerably lighter than formerly, while their durability has been notably increased.

As at first constructed, however, difficulties were experienced from irregular expansion between seat and valve, and it became necessary to keep the diameter of the valve as small as possible. This has been done by using double admission ports, and the valve chest has been jacketed and heated with the highest temperature steam. These modifications have made it possible to adopt a single size, 6 in. in diameter, of valve for the whole of the hot-steam locomotives of the Prussian State lines, even in the express engines with 23 in. cylinders. That these small valves run at the highest speeds without excessive throttling is to be attributed to the extreme mobility of the steam when highly

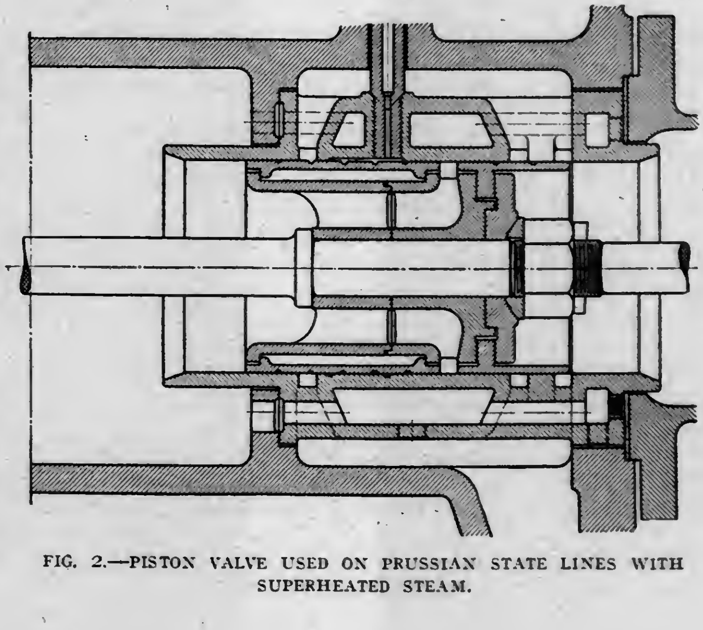


FIG. 2.—PISTON VALVE USED ON PRUSSIAN STATE LINES WITH SUPERHEATED STEAM.

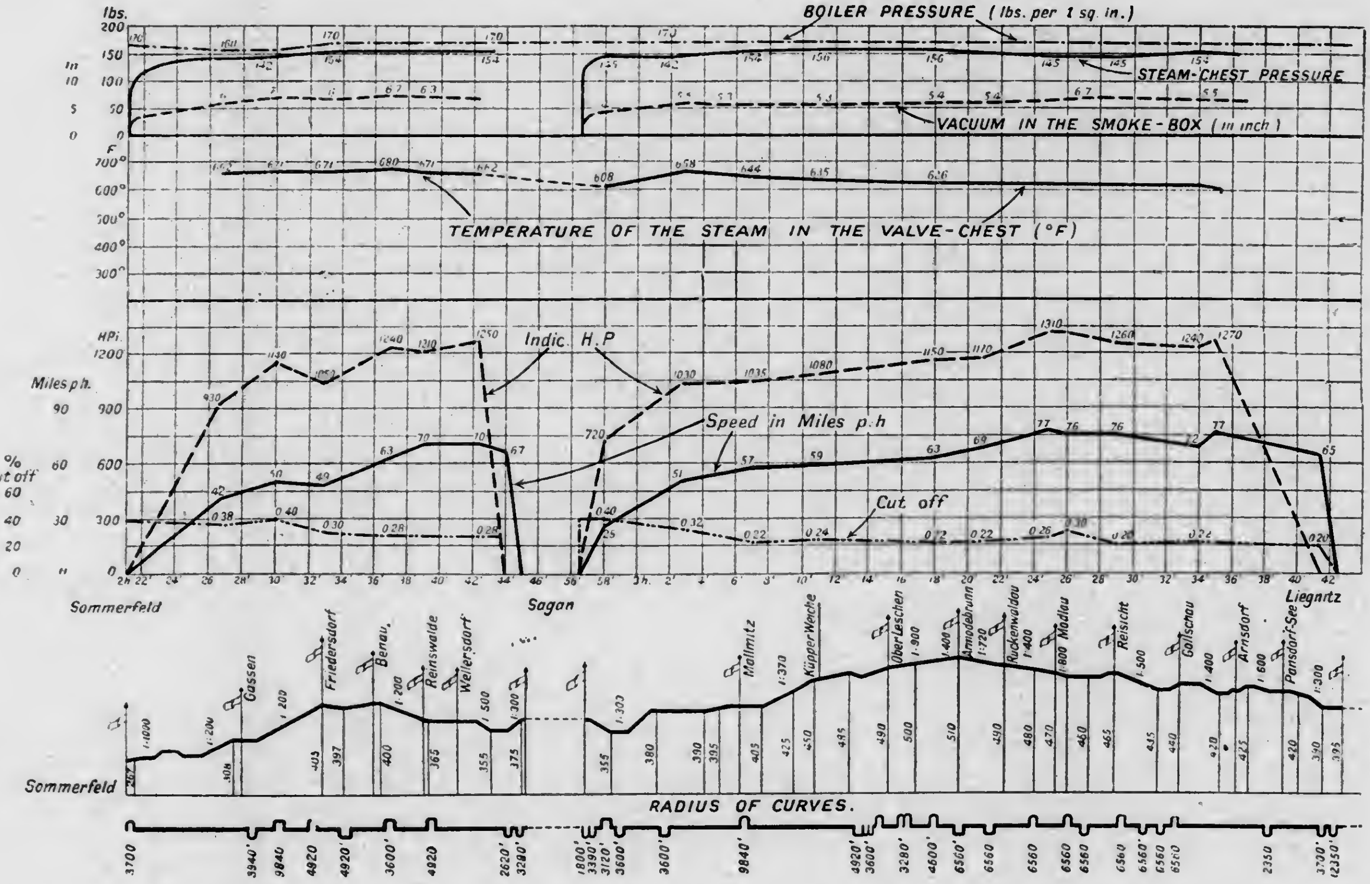


FIG. 4.—TRIAL RUN WITH A (4-4-0) SUPERHEATED STEAM LOCOMOTIVE WITH SCHMIDT SMOKE-TUBE SUPERHEATER, ON MARCH 31ST, 1906, FROM SOMMERFELD TO LIEGNITZ (67 MILES—PRUSSIAN STATE RAILWAYS).

Weight of carriages	301.6 tons	Heating surface, fire-box	132.5 sq. ft.
Weight of train	406.4 tons	" " tubes	1292.8 sq. ft.
Type of engine	4—4—0	" " superheater	341.2 sq. ft.
Diameter of cylinders	21.65 in.	" " total	1766.5 sq. ft.
Stroke	24.8 in.	Weight on driving-wheels	31.5 tons
Diameter of driving wheels	82.67 in.	Weight of engine in working order	56.7 tons
Boiler pressure	170 lb. per sq. in.	Weight of tender in working order	78.1 tons
Grate area	24.2 sq. ft.	Coal	5 tons
Water	4730 Brit. gals.		

superheated, and the advantages arising from the adoption of a single standard size of valve for all classes of engines will be apparent without further comment.

With regard to the objection raised by many authorities to valves of the construction described above on the ground of leakage, it must be remarked that the loss of steam measured when at rest is no measure of that taking place when running. These long close rings necessarily allow a considerable amount of steam to pass as a condition of maintaining their frictionless floating character when at rest, but such leakage decreases rapidly with increase of speed when in motion. A thin film of oil works into the clearance space between the valve casing, forming a perfectly satisfactory packing. Rings that have been long in use show no perceptible wear, but, on the contrary, their diameter may be slightly increased by a thin, compact deposit from the carbonizing of the lubricating oil on such parts as allow of its formation. This fact has been frequently observed. Finally, it may be remarked that small leakages into the cylinder during the admission and expansion periods are not prejudicial, and the loss during compression can only be insignificant. At any rate, the small power sacrificed from this cause bears no relation to the much greater amount required to work large flat valves or heavy unbalanced piston valves, to say nothing of the much greater wear and tear of the latter.

Piston slide valves have the defect that, unlike flat slides, the pressure on the seat is not diminished during running when the steam compression becomes too high. To avoid the injurious shocks in the rods and motion due to this cause, hot steam locomotives are provided with the contrivance shown in Fig. 3. This is a by-pass tube 2.35 in. bore, connecting the two ends of the cylinder, having a cock in the center. When the steam throttle is closed this is opened, and the pressure on both sides is equalized. This cock is steam-heated, and to prevent it becoming fixed on its seat, it is only loosely fitted, the steam pressure from either side keeping it tight in its place during running. The valve stem is connected by a grooved and dovetailed slide, and the grooves turned in the outer guide form a labyrinth packing, and so dispense with a stuffing-box. This is worked by hand with

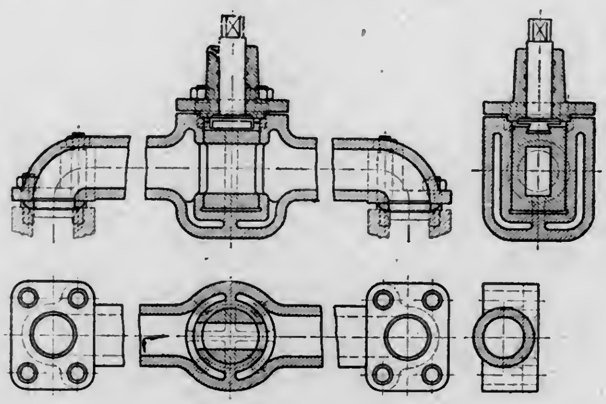


FIG. 3.—BY-PASS TUBE CONNECTING THE TWO ENDS OF CYLINDERS.

a key on the square end of the stem, and has taken the place of a former self-acting arrangement, which was not found to work

satisfactorily. The driver has to open the passage immediately on closing the throttle and must close it again before re-admitting steam to the engine.

Lubrication.—A matter of primary importance in the use of hot steam in locomotives is the provision of appropriate lubrication for the parts working under steam—the piston and slide valves—which, both in regard to material and arrangement, call for special modification in details.

The high temperature makes it necessary to use only pure mineral oils of particularly high flash points, which must be supplied to the rubbing surfaces in determinate quantity according to the speed, *i. e.*, the revolutions ot the driving wheels. It must be prevented from becoming mixed with water, or heated and decomposed by steam, both of which effects are more or less likely to occur with drop or sight feed lubricators. The access of condensed water to the surfaces to be lubricated is injurious to working parts, and is a cause of waste by the steam carrying finely divided oil to parts not requiring to be greased.

A further objection to drop lubricators in hot steam work is to be found in their inflexibility, the oil being distributed by a continuous flow from one or other end of the supply pipe in the direction of lower pressures, irrespective of the requirements of the surfaces. Now for successful lubrication, it is essential that it shall be possible to meet all variations of pressures on the rubbing surfaces by varying the supply of oil as necessities may arise. These considerations have led to the adoption of pressure lubricators. As the oil has to be supplied to three places on either side of the engine, two to the valves and one to the cylinder, the oil presses must be fitted with six cylinders, and the communication pipes must be kept constantly filled and under pressure, with appropriate return valves at the distributing points. The return valves or oil savers are important features in the arrangement, preventing irregularity of flow from changes of pressure in the places to be lubricated, and the waste of the oil from the supply pipes when the engine is standing or running without steaming for any length of time.

Special Equipment Details.—In addition to the items described above, certain special fittings are required for the hot steam locomotive. These include a pyrometer and a pressure gauge for determining the superheat and pressure at the valve chest, a smoke-box vacuum gauge, and a hand rod for the pressure equalizer, placed near the hand wheel of the valve gear. The handle for regulating the superheater flap valve is placed on the left-hand side of the fire-box.

TRIALS.

From the large amount of accumulated experience obtained on trial trips and in ordinary working with hot steam locomotives, only a few important points will be selected.

From the results of working alone it is not, however, easy to form a correct opinion as to the actual economy in consumption, as in many cases both handling and maintenance of hot steam locomotives leaves much to be desired. The much more favorable results obtained on trial trips are to be regarded as ideal maxima obtainable by the method, and that these are not realized in continuous working is to be attributed to the circumstance that the size of the trains and the running times are arranged to meet the conditions suited to the best and most economical working of the ordinary locomotives, and not those suited to the much higher capacity of superheat locomotives. Notwithstanding these drawbacks, the average saving of coal as derived from practical working with superheated steam is from 25 to 30 per cent. of the consumption of simple and 15 to 20 of compound engines using saturated steam.

Increased Working Capacity.—The working results of a superheated steam locomotive on the Prussian State lines is represented graphically in Fig. 4.

The brilliant results are so clearly expressed in the figures that further explanations will be superfluous. Similar results have never been obtained with saturated steam in engines of the same weight and number of axles, and when it is remembered that they have been accompanied by important savings, it can no longer be doubted that the adoption of highly superheated steam in the simple two-cylinder locomotive affords the best means of increasing the power of the locomotive while retaining simplicity of construction.

Construction and Maintenance Cost.—Having thus demonstrated the advantages of the system, the objections made on the ground of greater costliness remain to be considered. The extra cost due to the superheater, and the increased size of some of the working parts, having regard to the necessary advantages already noticed, and the practical abolition of double heading, are comparatively small, and with the unification of the details, and their production on a large scale, are likely to be considerably reduced.

It will be easily understood that during the experimental period many mistakes were made. Every new form brought its own problems with it, and the experience gained with each has been utilized in its successor, so that at present the desired simplicity has been attained, and the accumulated experience as to the durability of the superheater and other parts, and the work required for their maintenance, is uniformly favorable.

As regards the cost of maintenance, the experience with smoke tube superheaters on the Prussian State Lines extends over too short a period to allow of a final estimate being formed, but their excellent behavior in current work, together with the much larger experience of foreign railway companies, justifies the opinion that no difficulties are to be anticipated on this ground.

It is, however, essential that the regulations for tube cleaning shall be rigorously observed, as, if this is not thoroughly done, deposits accumulate in the tube, diminishing the free draft of the heating current, with a necessary lowering of the heating power.

ADVANTAGES OF HAVING CAREFULLY PREPARED SPECIFICATIONS.—When competing manufacturers are furnished with carefully prepared specifications, and if necessary, drawings also, showing exactly what is wanted, they are then able to figure the closest prices they can afford to name without having to make any allowances for uncertainties. When definite specifications or drawings establish a fair and exact basis for comparing the relative merits of bids, manufacturers will ordinarily submit lower prices for material of the quality specified than they would do otherwise. If a manufacturer feels that certain railroad companies will repeatedly purchase from him in large quantities articles of exactly the same kind, and will not change their standards without excellent reason, he will ordinarily quote very low figures hoping thereby to secure such business continuously. By concentrating orders for the same devices or materials with one, or in a few cases with two, well equipped and reliable manufacturers, more uniformity can be secured, and the ordering, inspection and forwarding of shipments are facilitated and accomplished with greater economy. Another great advantage in having intelligent and definite specifications and drawings is that it facilitates a fair inspection, and, when articles are furnished in accordance with definite conditions, there is far less uncertainty as to results that will be obtained by their use.—*W. V. S. Thorne before the New York Railroad Club.*

HANDLING OF COMPANY COAL.—As a rule the office of fuel agent comes under the mechanical department. The fuel agent endeavors to buy coal where he can get the most heat value for the price he pays. This is sometimes worked out mathematically by making coal tests to determine the value of various coals and then distributing them according to price and length of haul without any regard to the car situation, the grade of the road and of the direction in which the volume of business is traveling. A system of coal distribution which might be ideal from the purchasing agent's standpoint might be very uneconomical under certain operating conditions, and if the fuel agent is not broad gauge enough to see into and allow for practical conditions he will probably waste a good deal of money before being checked. He must keep in touch with the car service and operating officials as well as with the coal situation to get best results.—*Dexter C. Buell before the Central Railway Club.*

(Established 1832).

AMERICAN ENGINEER AND RAILROAD JOURNAL.

PUBLISHED MONTHLY

BY

R. M. VAN ARSDALE

140 NASSAU STREET, NEW YORK

J. S. BONSALL,
Business Manager.

R. V. WRIGHT, } Editors.
E. A. AVERILL, }

SEPTEMBER, 1908

Subscriptions.—$2.00 *a year for the United States and Canada;* $2.50 *a year to Foreign Countries embraced in the Universal Postal Union. Remit by Express Money Order, Draft or Post Office Order. Subscription for this paper will be received and copies kept for sale by the*
Post Office News Co., 217 Dearborn St., Chicago, Ill.
Damrell & Upham, 283 Washington St., Boston, Mass.
Philip Roeder, 307 North Fourth St., St. Louis, Mo.
R. S. Davis & Co., 346 Fifth Ave., Pittsburg, Pa.
Century News Co., 6 Third St., S. Minneapolis, Minn.
W. Dawson & Sons, Ltd., Cannon St., Bream's Buildings, London, E. C., England.

Advertisements.—*Nothing will be inserted in this journal for pay,* EXCEPT IN THE ADVERTISING PAGES. *The reading pages will contain only such matter as we consider of interest to our readers.*

Contributions.—*Articles relating to Motive Power Department problems, including the design, construction, maintenance and operation of rolling stock, also of shops and roundhouses and their equipment are desired. Also early notices of official changes, and additions of new equipment for the road or the shop, by purchase or construction.*

CONTENTS

The railroad clubs in various sections of the country were primarily organized to give the railroad men of the districts in which they were located, the opportunity of getting together and becoming better acquainted, and to study the various problems with which they were confronted and gain the benefit of each other's knowledge in their solution. Some of the clubs have made their proceedings of so great value and have exerted so strong an influence on the development of mechanical department affairs that they may almost be classed in importance with some of the national engineering organizations. In a few instances they draw their membership not only from all parts of this country, but also from abroad.

The column entitled "What the Railroad Clubs Will Do in September," on page 369 of this issue, is intended not only to direct special attention to the work which these clubs are doing, but to assist our readers in getting into closer touch and making better use of them. With the co-operation of the club officers we believe that this column can be made of sufficient interest and value to warrant its appearance each month. We shall appreciate any expressions from our readers as to the advisability of continuing it, or of its value to them.

A study of Mr. Evans's article on "A Practical Drawing Office System," the second and concluding part of which appears in this issue, must convince the reader that the Canadian Pacific mechanical department drawing room system is in very many respects an ideal one. The method of keeping the maintenance regulations up to date and readily accessible to all those who are interested in them presents a delightful and refreshing contrast to the careless, hit-and-miss fashion in which this matter is handled on many roads. Best of all, it is so simple, and comparatively inexpensive to install, that there is no reason why it cannot be adopted generally.

Equally as good is the method of keeping the tracings up to date, keeping the revised drawings in the hands of those interested, and the method of distributing the blue prints. When one considers the intricate methods of keeping track of the revisions and corrections in use on some of the larger roads, often entirely beyond the ability of the average foreman to understand, and even puzzling to the draftsmen, and the hopelessly tangled condition in which the blue prints are often found at division points, there being no certainty on the part of those who wish to use them as to whether they are of the latest issue or not, the simplicity and efficiency of the system described by Mr. Evans makes a special appeal.

Estimates based on tests which were made on freight and passenger locomotives on a western road indicate that probably about 4 per cent. of the steam generated in a locomotive boiler is used by the air pump. A large part of this 4 per cent. could be utilized by exhausting it into the tank and heating the feed water. From time to time different roads have tried to do this and they have even gone so far as to equip large numbers of their tanks with the necessary piping. In some instances the exhaust has been turned directly into the water in the tank; in others it was feared that the oil in the exhaust would have a bad effect and the steam was passed through piping in the tank and condensed, giving off its heat to the feed water, the water from condensation being drained off.

The difficulty seems to have been that the injectors would not work after the temperature had reached a certain point. It was necessary to have a three-way cock so arranged that the exhaust from the pump could be diverted from the tank to the front end and this necessarily placed the operation of the device under the control of the engineer. In some instances the injector after it had become worn would refuse to handle the water at a very much lower temperature than when it was in good condition. If the temperature became too high and the injector refused to work the engine crew would of course find themselves in a rather awkward predicament.

Either from lack of interest on the part of the crew or because

they were afraid of getting the water too warm and stopping the injectors from working, the device was not used as much as it should be and gradually fell into disuse on the roads upon which it had been adopted. Attempts have been made to provide an automatic arrangement to divert the exhaust from the tank after the temperature had reached a certain height, but unfortunately these have apparently never been a success.

On the above-mentioned road the average temperature of feed water on the various divisions, and for the entire year, is in the neighborhood of 55 degrees, or 45 degrees lower than the temperature at which it can safely be put into the injector. Assuming that the steam delivered to the air pump and exhausted into the tank has dropped from 1,200 to 1,000 heat units by the time it reaches the tank, which allows for the loss of heat during condensation and the work done in the air pump, it is estimated that an average saving of 2½ per cent. could be made by the intelligent use of the air pump exhaust, taking into consideration that a large amount of the water would enter the injector before the temperature had been brought up to the limit of 100 degrees. It would seem as if the savings to be effected in this direction were sufficient to warrant the expenditure of considerable energy to develop some satisfactory means of utilizing this waste steam.

The following question was recently submitted to us: "The mechanical department judges the condition of power with respect to how soon back shop repairs will be needed on it. The operating department judges the condition of power with respect to its ability to move trains at the instant called for by them. A master mechanic may have his power in good condition, as far as the back shop is concerned, yet have a large percentage tied up waiting for minor roundhouse work. One man says the power is in good condition, the other says it is rotten. Who is right?"

The most reasonable answer would seem to be that the two departments should get together on some common basis of comparison. As a matter of fact, neither one of the two departments is an end in itself, but they should work together for one common object, i. e., good service to the patrons of the road and the largest possible earnings consistent with this. Results are what are wanted, and the maximum efficiency of the organization can only be secured by having the hearty cooperation of the different departments and by, as far as possible, eliminating all unprofitable discussion. If power is not available when it is wanted it would seem that its condition for the time being was poor and the aim should be to prevent this from happening as much as possible. Power is often needlessly placed temporarily in bad condition due to the lack of foresight and cooperation on the part of the operating department with the motive power department.

The instructions issued by the executive committee of the Master Car Builders' Association, to govern the committees in the preparation of their reports for the 1909 meeting, will commend themselves to all who are interested in the work of that organization. They are reproduced on another page of this issue. The work of this association is becoming so important and has such far reaching effects that action on any subject should be taken only after mature deliberation. Placing the committee reports in the hands of the membership about May 1st will enable the officers of the different roads to discuss the matters carefully, not only with their assistants and subordinates, but with officers of such of the other departments as might be more or less affected by any action taken. At the convention they will then be in a better position to discuss the various questions intelligently and to protect the interests of the road with which they are connected. The thorough discussion which will result will enable the membership to vote more intelligently on such questions as may be submitted to letter ballot. The necessity of reading reports in full, which is usually a tiresome and unprofitable proceeding, can be done away with and it will be only necessary to open the discussion of each subject by presenting a brief abstract of the report. That the instructions promise to be effective is shown by the fact that several of the committees have already held meetings and taken the preliminary steps toward the preparation of their reports. It is to be hoped that the executive committee of the Master Mechanics' Association will take similar action.

In this connection it is important for the roads represented in the association to realize that it is to their best interest to have as large a representation as possible at the convention meetings. While questions of standards and recommended practice are submitted to letter ballot and each road has a certain number of votes, depending upon the amount of equipment which it operates, still the preliminary action leading up to this is decided by the majority vote of the members present at the meetings. A study of the roads represented at the Master Car Builders' Association meetings indicates that a few of the roads have apparently studied closely the effect which any action of the association on different subjects may have on their particular road. They apparently find it to their interest to have as large a representation as possible at the meetings and it is interesting to note the team work which often takes place in pushing and placing before the convention such matters as are apparently of special interest to some one of these roads. That other roads do not seem to realize the importance of this is indicated by the small representation for some of them, and the fact that apparently the members who are present have not studied the subject over together and outlined the policy which would give the best results for their particular road.

MOTOR CARS.

[*Editor's Note.—We were greatly pleased, shortly after the August issue was mailed, to receive letters from two prominent engineers, both of whom have devoted considerable study to the motor car question, congratulating us on the stand which we took in the editorial on "Motor Cars." The following letter was received just as we were about to go to press, otherwise we would have secured permission to print the other two letters in connection with it.*]

TO THE EDITOR:

In the AMERICAN ENGINEER AND RAILROAD JOURNAL for August, page 312, is an editorial criticising, in a general way, the development of the single unit motor car for railway purposes. It is stated that a number of cars have been built in this country and elsewhere, during the last few years, and proved failures from one cause and another. True, many of these cars, or rather the development, have been failures, from the fact that in many cases a very limited appropriation has been made to some railroad mechanical officer to build an experimental car; and, about the time the real work of the development was to commence, the small appropriation has been used up, and the work stopped.

The editorial states: "It is impossible to care for the former in the same place and manner as other motive power on the road is cared for." The railroads of the country have been working for from twenty-five to fifty years, developing terminal facilities for the economical handling of cars and locomotives; and, naturally, the installation of the service of motor cars, in connection with locomotive equipment, would cause some little confusion for a short time. Electric traction cars and automobiles are satisfactorily cared for in houses arranged with a view to their economical handling, and the fact that steam railroad terminal facilities are not entirely adequate to meet the requirement for economically handling single unit motor cars, is not a just criticism against the motor car as it stands to-day. In case of repairs, however, the entire car is naturally put out of commission. And, with the steam locomotive and train, we have the locomotive and one or possibly two coaches, any one of which may be put out of commission.

The cost of development of any piece of mechanism is very much greater than the selling price for the same article at a later date, when standards have been arrived at, and the cost of construction has been brought down to a minimum. Even as

a new development, the single unit motor car can be built to-day for very much less money than a small locomotive and coach. On a cost per pound basis, the motor car has very much in its favor. An objection is made to the necessity of carrying an extra unit to maintain service. There is probably no class of mechanism in the country to-day requiring more extra units than the steam locomotive. Traction lines figure on an extra unit for every four or five cars.

The objections to "a small, highly specialized locomotive, preferably of the 0-4-0 type, attached to a combination coach," are a higher cost of operation; higher first cost of equipment; necessity of say four men in place of two for the operation; and serious objection to the smoke and cinders from any steam locomotive, especially in interurban service, where so many stops are made. This last objection is met with in the case of a steam motor car burning coal; but, with the gasoline car or gasoline electric car, this very objectionable feature is done away with—making travel a pleasure rather than an irksome task.

C. B. Smith, Asst. Mech. Engr.
Union Pacific Railroad Co., Omaha, Neb.

FUEL ECOMOMY.

An interesting and valuable report on the question of smoke prevention and fuel economy was presented at the recent meeting of The Traveling Engineers' Association. The report was based largely on the replies to a series of questions which were submitted to the members and the following is an abstract of the most important parts of it.

A synopsis of the replies received, boiled down, results in the following conclusions: That fuel economy can only be effected through education; but that this education must not be confined to simply teaching the firemen how to fire or the engineer how to work his engine economically, but must extend from the bottom to the top, that is, from the man at the mines to the highest officer of the road, so that all will know and realize the importance of the subject and by their help and co-operation assist to bring about the desired results.

The efforts of the traveling engineer are confined principally to the men in the cab, and while very effective so far as they go, do not by any means accomplish all that could be done, were he granted full, absolute and extensive support. While granting that the traveling engineer is given a certain amount of support from the upper quarters, yet candor compels us to say that this support, except in a few notable instances, is of but an intermittent and perfunctory nature, and therefore as a whole not lasting and of little actual value. This, however, is not through any spirit of laxity or indifference on the part of the higher officials, but is brought about by conditions, and the fact that the average official on the American railroads is saddled with so many duties or has such an extensive territory that it becomes a hard matter to give each specific duty the attention that it deserves. With the mechanical man fuel economy is subordinated to maintenance of equipment and with the transportation man it is ranked by moving traffic, and, consequently, between the two the traveling engineer often fails to accomplish his ends simply for lack of proper support. Fuel economy and the results that can be obtained are of sufficient moment to warrant any railroad in putting on a special man to look after this one feature alone.

Do firemen study? The replies would indicate that firemen as a rule do not study to advantage. The free literature distributed by the various railroad companies on the subject of fuel economy is appreciated, but the men are more inclined to absorb the information through oral instructions and practical demonstrations. This, however, must not be taken as an argument against written or printed instructions. It simply proves the necessity of education along that line. The average fireman does not at first realize that he is simply an apprentice engineer and that when he reaches that position more will be required of him than simply 200 pounds of steam, and therefore does not care to puzzle his cranium with the problems of combustion, but takes his knowledge in the easiest form and less troublesome doses.

It has been noticed, however, that where firemen have through study mastered the principles of combustion they usually stand at the head of the list of firemen, and likewise after promotion to engineers they can do their work easier and better than their less educated brothers. The habit of applying brains to their work, formed when firing, remains to their after-advantage as engineers. As the future fireman will use his head as much as his back, we urge that all study be encouraged and to aid him to master what to many is a difficult lesson, that teachers or instructors or demonstrators (whatever you may call them) be employed to help the willing firemen over the rough places. The unwilling man has no place on an engine.

Assistant road foremen. We most emphatically advocate the employment of competent instructors, but would not call them traveling firemen, but assistant traveling engineers or assistant road foremen. They should have authority over the engineer as well as over the fireman, as without this authority, unless possessed of infinite tact, they might do more harm than good.

The assistant traveling engineer should be recruited from the ranks of engineers and should be a young, active and energetic man, one who can take the scoop when necessary and demonstrate to the fireman the correct way to handle it and get results —namely, the maximum amount of steam from the minimum amount of coal. In addition to being young and active and a first-class fireman, he should also be a first-class engineer, one who can, if necessary, demonstrate to the man on the right side of the engine how he can handle the engine to better advantage and, by so doing, help himself, the fireman and the company. This man would naturally fall in line for the position of traveling engineer when the latter is promoted. He should be subordinate to the traveling engineer and should either work directly under or else in harmony with him.

Inspection of ash-pans, etc. Most roads require this and all intelligent firemen naturally do it. A few trips with the air openings stopped up soon convinces the fireman of the advantage of keeping them open, and the lesson once learned is not soon forgotten.

Instruction to fireman to keep the door closed, etc. This is another lesson that is soon taught by a little experience, but it is always advisable to teach it direct, instead of letting the fireman find it out for himself, as the opening of the door and leaving it wide open while the engine is forced to the limit in lifting the train to speed, is apt to cause other damage: leaky flues, etc.

When should grates be shaken? This depends largely on local conditions, the nature of the coal, etc.; all are agreed, however, on the manner in which the grates should be shaken, namely by short, quick jerks, and not a slow, rocking motion. All are also practically unanimous that as a rule it is much better to shake the grates when the engine is drifting or working light than when being worked hard.

Comparison of heating value of coal. This is a refinement in comparison to men and engine efficiency that is practiced by but few roads. We recognize the fact that it is not always practical on all roads and, except for a basis of comparison, is unnecessary. We believe, however, that comparison should not be made between two different divisions, unless all conditions are exactly similar, not forgetting density of traffic.

The comparison should only be made between similar engines in the same class of service on the same divisions, but even that comparison cannot simply be made between passenger and freight, work and yard engines, on a ten-mile basis, with fairness, where regular engines are assigned to and kept, through and local passenger service, fast, slow and local freight, etc., as in that case, to be absolutely fair, comparison should be on a ten-mile-per-hour basis. Time is the one important consideration that is often lost sight of in making any comparison.

Instruction of firemen on front end appliances, etc. Too much information on any part of the locomotive cannot be given to the fireman or, for that matter, to any one else whose duties throw him in contact with engine service. Where it may not be practical to move a draft sheet up or down in order to give the fire-

man ocular demonstrations of its effect on the burning of the fire, yet the information to that effect and also the object of the different front end arrangements should be carefully explained, as the fireman knowing this can at once tell by the action of the draft on the fire if anything has become loosened or misplaced in the front end, in which case repairs can often be made before failure results.

Premiums. It is the sense of this Association that monetary premiums do not have the desired effects; in fact, quite the contrary seems to be the case, as it has been found to lead more toward sharp practice on the part of the men than actual economy, and consequently the company is little if any the gainer.

It is our opinion that it is more preferable to encourage a spirit of friendly rivalry among the men and to hold out advancement and promotion as a premium, instead of a small financial remuneration. We further believe that comparison between the efficiency of engines and men should be made on a ton-mile basis between those in absolutely similar service, and a monthly bulletin posted, showing the standing of different men. This bulletin can show the standing in dollars and cents, showing how much more one man cost the company to perform a certain amount of work than another. In addition to this bulletin, however, we favor giving letters of commendation to those at the head of the list, and friendly letters of admonition to those at the foot. If it is finally found that letters of admonition have no effect on the latter, it is well to drop them from the service, as it has been found that any man who cannot be reached through his pride cannot be reached in any other manner, consequently he is unfit for railroad service.

Where firemen are obtained. As one of our past presidents so aptly expressed it, "You would not hesitate to pick a $20.00 gold-piece out of the mud," so it makes little difference where you get your firemen, provided they are the right material. This is governed largely by local conditions and environment. My experience has been that the best men are recruited from the rural districts. As for early training, the common practice seems to be to let the applicant make student trips on freight engines, usually without pay, with experienced firemen and continue to make these trips until competent to go alone. This is usually a good tryout, as any man who will follow a modern engine for twenty or thirty days for nothing, in order to learn to fire, evidently wants the job and will no doubt stick.

Student trips. For examination, as mentioned above, student trips appear necessary, and there should be as many as required to win the approval of the traveling engineer or, in his absence, of three competent engineers with whom the applicant has made student trips.

Progressive examinations are heartily endorsed, as they appear to be the only way in which the majority can be induced to study and perfect themselves, and also a way of getting rid of undesirable men when conditions justify. In conclusion, we find the entire matter resolves into a campaign of education, and therefore everyone should be encouraged to acquire knowledge.

We must not forget, however, that as a fireman becomes better educated he becomes more observant and consequently we cannot with very good grace keep hammering him to save coal, etc., while at the same time we let him see that for each scoopful he saves on the road a ton is wasted about the roundhouse and coaling stations. He will be apt to say, "Why don't you practice what you preach?" showing that there are others who need education on fuel economy besides the fireman.

Above all, however, when you find an engine crew or, in fact, anyone trying hard to make a showing or a saving, don't forget to encourage them.

RECORD IN TUNNEL DRIVING.—The contractor driving the tunnel at Taft, Mont., on the route of the Chicago, Milwaukee & St. Paul road's Pacific Coast extension, during the month of June pushed the bore 583 ft. deeper into the mountain. This is said to be a record. When completed the tunnel will be 8,571 ft. long. On August 1st it was 4,388 ft. long.

MASTER CAR BUILDERS' ASSOCIATION COMMITTEES.

The executive committee of the Master Car Builders' Association is to be heartily congratulated upon the stand it has taken, as to the preparation of committee reports and the limitation as to the time of submitting them, as indicated by the circular recently issued by the secretary, Mr. Taylor. It is to be sincerely hoped that they will rigidly enforce these regulations.

This circular and the names of the chairmen of the various committees are as follows:

In order to expedite the work of the convention of 1909, the following instructions regarding the preparation and presentation of the reports of committees were adopted by the executive committee at a meeting held in Chicago, Ill., on July 15, 1908.

1. That all active, representative and associate members of the Association, immediately on receipt of this circular, transmit to the chairman of the respective committees all the information they may have on each subject, which they consider will be of assistance to the respective committees in preparing their reports.

2. That the chairmen of all standing and special committees prepare their circulars of inquiry and submit the same to the secretary for printing and issuing prior to September 1, 1908.

3. That prompt replies be made to the circulars of inquiry as issued by the different committees.

4. That the chairmen of all standing and special committees must have their reports in the office of the secretary not later than April 1, 1909, in order that the same can be printed and advance copies issued by May 1, 1909.

5. Committee reports which do not reach the secretary in time for printing and issuing by May 1, 1909, will be referred to the executive committee to decide whether the report shall be submitted to the convention.

6. That abstracts only of all reports of standing and special committees be read by the chairman of same before the convention, together with whatever additional data may have been accumulated after April 1, 1909, to the date of the convention.

7. That the members of standing and special committees who may individually or collectively submit a minority report, must prepare the same so that it can be issued with the report of the majority of the committee, and substituted for the majority report in the event the convention should so decide.

8. That each member of a standing or special committee sign either the majority or minority report.

CHAIRMEN OF STANDING COMMITTEES.

Arbitration.—J. J. Hennessey, M.C.B., C., M. & St. P. Ry., West Milwaukee, Wis.

Standards and Recommended Practice.—T. S. Lloyd, S.M.P., D., L. & W. R. R., Scranton, Pa.

Train Brake and Signal Equipment.—A. J. Cota, M.M., C., B. & Q. R. R., Chicago, Ill.

Brake-Shoe Tests.—W. F. M. Goss, University of Illinois, Urbana, Ill.

Coupler and Draft Equipment.—R. N. Durborow, S.M.P., Pennsylvania R. R., Altoona, Pa.

Rules for Loading Materials.—A. Kearney, A.S.M.P., N. & W. Ry., Roanoke, Va.

Car Wheels.—William Garstang, S.M.P., C., C., C. & St. L. Ry., Indianapolis, Ind.

Safety Appliances.—C. A. Seley, M.E., C., R. I. & P. Ry., Chicago, Ill.

CHAIRMEN OF SPECIAL COMMITTEES.

Freight Car Trucks.—A. Stewart, G.S.M.P., Southern Railway, Washington, D. C.

Splicing Sills.—R. E. Smith, G.S.M.P., A. C. L. R. R., Wilmington, N. C.

Freight Car Repair Bills.—J. F. Deems, G.S.M.P., N. Y. Central Lines, New York City, N. Y.

Air-Brake Hose.—LeGrand Parish, S.M.P., L. S. & M. S. Ry., Cleveland, Ohio.

Side Bearings and Center Plates.—R. D. Smith, A.S.M.P., B. & A. R. R., Boston, Mass.

Painting Steel Cars.—G. E. Carson, M.C.B., P. & L. E. R. R., McKees Rocks, Pa.

Side and End Door Fixtures.—C. S. Morse, M.C.B., W. & L. E. R. R., Toledo, Ohio.

Tank Cars.—A. W. Gibbs, G.S.M.P., P. R. R., Altoona, Pa.

Train Pipe and Connections for Steam Heat.—C. A. Schroyer, S.C.D., C. & N. W. Ry., Chicago, Ill.

Classes of Cars.—J. E. Muhlfeld, G.S.M.P., B. & O. R. R., Baltimore, Md.

Salt Water Drippings from Refrigerator Cars.—M. K. Barnum, Asst. to V.-P., C., B. & Q. R. R., Chicago, Ill.

Revision of Constitution and By-Laws.—D. F. Crawford, G.S.M.P., Pennsylvania Lines, Pittsburgh, Pa.

Subjects.—H. D. Taylor, S.M.P., P. & R. R. R., Reading, Pa.

Arrangements.—R. F. McKenna, G.F.C.D., D., L. & W. R. R., Scranton, Pa.

SUCTION GAS PRODUCER POWER

By L. P. Tolman.

It is estimated that there are over 500 producer power plants in this country, having an aggregate of 150,000 horse power. Of these, about eighty-five per cent. are of the "suction" type and fifteen per cent. of the "pressure" type. The suction plants average approximately 100 horse power each, while pressure plants are usually built in sizes larger than 1000 horse power. This article deals with suction gas power plants in single units of 200 horse power, or smaller, and complete plants made up of a number of such units, 1000 horse power, or larger. This range of sizes covers the requirements of the great majority of power users.

Comparative Waste with Steam and Producer Gas Power.

Fig 1 illustrates a modern steam plant with its many complications, including compound condensing steam engine with water tube boiler. This plant converts 8 per cent. of the total energy of the fuel into useful work (in actual practice the percentage utilized is usually less). In other words, 92 per cent. or more of the energy in the coal goes to waste as smoke exhaust from the engine, heat radiation, etc. A 150 horse power steam plant of this type, running at two-thirds load, 3100 hours per year, uses approximately 4½ pounds of coal per brake horse power per hour. With coal at $2.75 per ton, the fuel alone costs $1,918.12 per year. In addition, the cost of attendance is a large item of expense, and the boiler, especially, calls for constant attention, cleaning, and repairs.

The ordinary throttling governor steam engine with tubular boiler, a type which is in very general use, especially in sizes from 15 to 200 horse power, is shown in Fig. 2. This plant converts 5 per cent (though usually much less) of the total energy of the fuel into useful work. In small steam plants the total amount of energy utilized is often not over 2 or 3 per cent. In other words, 95 per cent. or more of the energy in the coal goes to waste as smoke exhaust from the engine, heat radiation, etc. A 150 horse power steam plant of this type, running at two-thirds load, 3100 hours per year, uses approximately 7 pounds of coal per brake horse power per hour. With coal at $2.75 per ton, the fuel alone costs $2,983.75 per year. In addition, it requires the entire time of at least one man to operate the plant. The boiler, especially, requires constant care, cleaning and repairs, and is always a source of danger.

A suction gas producer power plant is shown in Fig. 3. The apparatus is simple, reliable and very economical. With this plant 18 per cent. of the total energy of the fuel is converted into useful work (varies according to conditions, from 15 to 21½ per cent.). This means that a suction gas producer plant uses from one-half to one-fourth as much coal for a given amount of power as a steam plant. A 150 horse power suction producer plant, running two-thirds load, 3100 hours per year, uses approximately 1½ pounds of coal per brake horse power per hour. (Tests have been made showing a consumption of less than 1¼ pounds at two-thirds load and less than 1 pound at full load.) With anthracite at $5.00 per ton, the fuel alone costs $1,162.50 per year. Furthermore, the cost of attendance can be reduced materially with a producer plant, as the operator can spend part of his time in other useful work.

Much valuable information is given in the report of the United States Geological Survey concerning the fuel testing

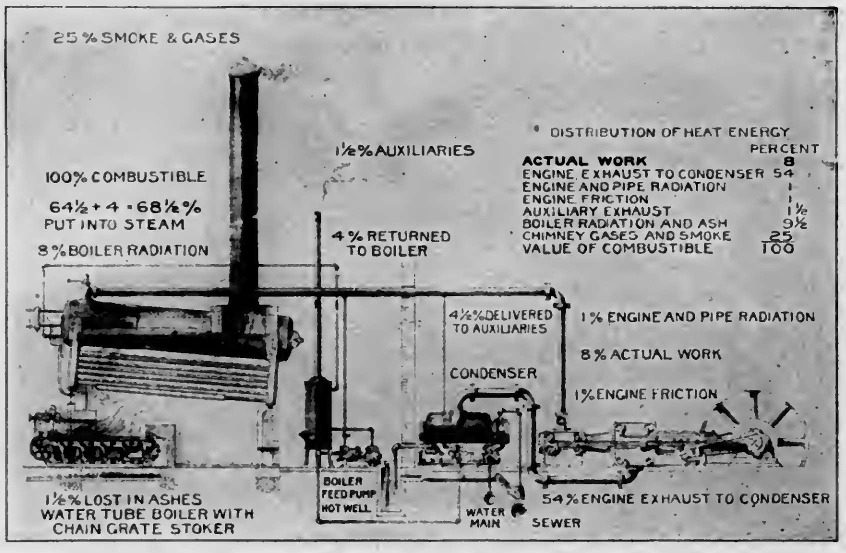


FIG. 1.—COMPOUND CONDENSING STEAM PLANT.

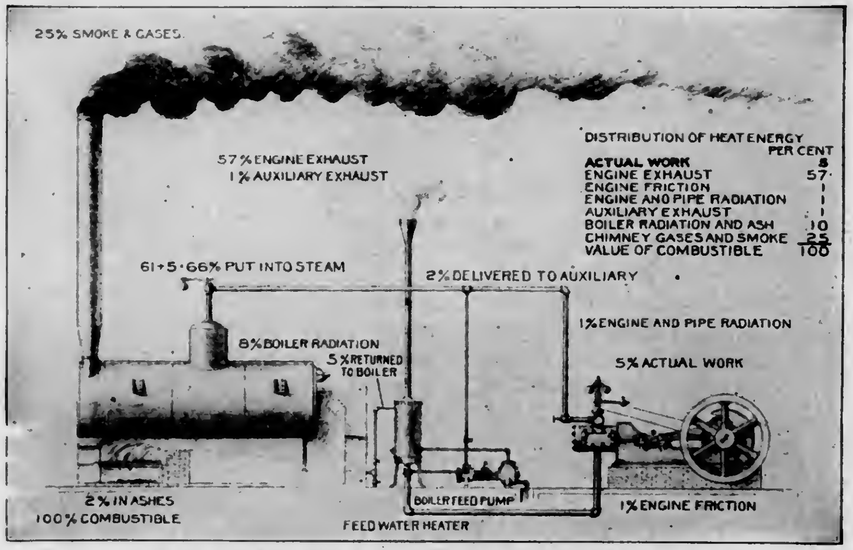


FIG. 2.—SIMPLE STEAM ENGINE AND TUBULAR BOILER.

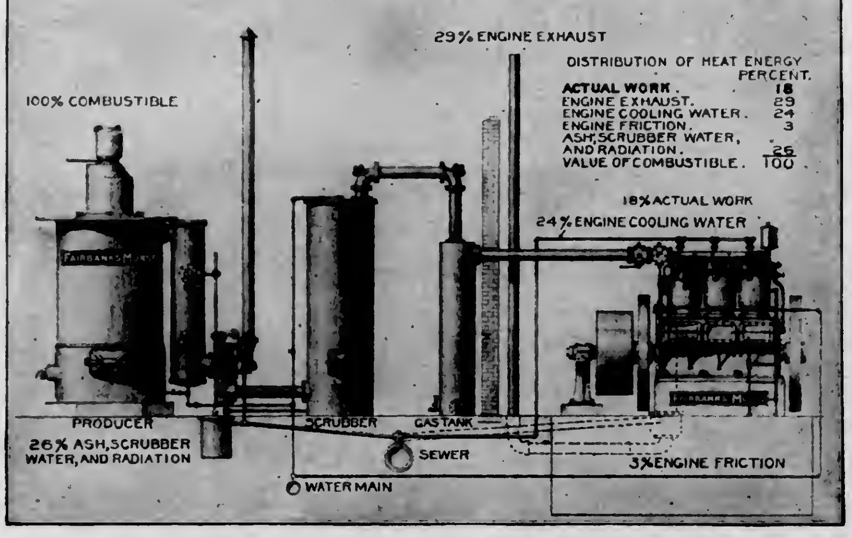


FIG. 3.—SUCTION GAS PRODUCER POWER PLANT.

plant at the Louisiana Purchase Exposition, St. Louis, Mo. For three years the Government experts conducted a series of tests on many samples of coal from mines all over the country. Briefly, the apparatus included a non-condensing Corliss engine steam plant with a water tube boiler and a pressure type producer with a three-cylinder vertical gas engine.

From the summary of results obtained from a long series of tests, the fuel consumption in the pressure type producer plant varied from 1.18 to 3.47 pounds per brake horse power per hour, the average being approximately 1¾ pounds. The average with the Corliss steam plant was found to be approximately 4½ pounds, using similar fuels. With lignite, the consumption in the pressure producer plant was from 1.95 to 3.47 pounds, the average of five samples actually figuring 2.60 pounds. With the Corliss steam plant using lignite, the average consumption of "coal as fired" (not "dry coal") was approximately 7 pounds.

While most of the above tests were on bituminous coals, which cannot be used advantageously in a suction producer, yet the consumption of anthracite in the latter is usually less than as stated for bituminous coal in the "pressure" type producer, probably due to the fact that there is less resistance to the flow of gas in the suction type. For example, tests on lignite in a suction producer commonly show a consumption of 2 to 2¼ pounds, whereas from the five lignite tests at St. Louis the average is 2.60 pounds in a pressure producer plant.

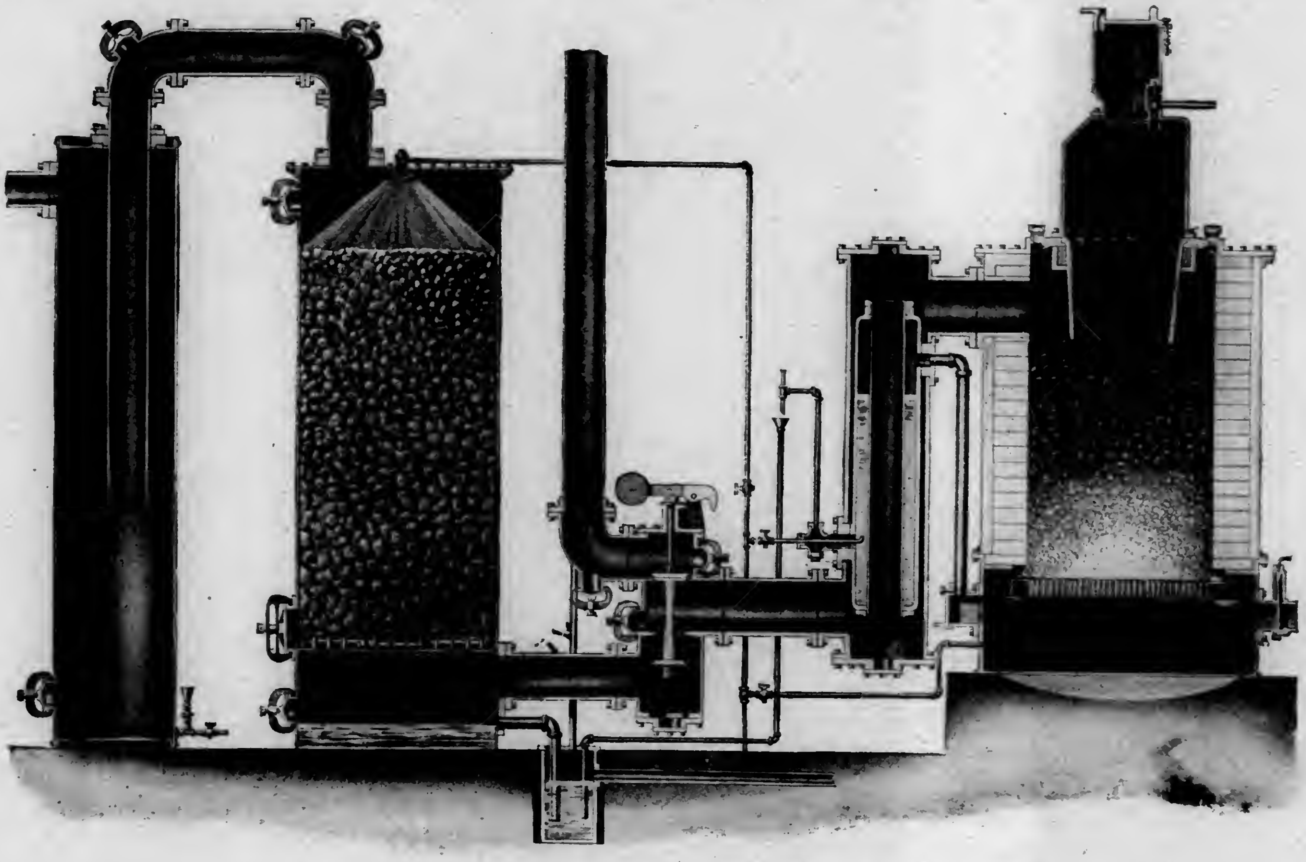


FIG. 4.—SECTIONAL VIEW OF FAIRBANKS-MORSE SUCTION GAS PRODUCER.

Advantages of Suction Gas Producer Power.

We have already discussed the high thermal efficiency of the suction gas producer plant. The most important and the most practical commercial advantage is the economy effected in the cost of developing power. If there were no other advantages, this one feature would be sufficient reason for installing this system. Other advantages may be summed up briefly:

The producer, in which fuel gas is generated from coal, is almost as simple as an ordinary furnace for heating purposes. The gas engine is entirely automatic in operation and needs little more than the ordinary cleaning and care as to lubrication.

There is no danger from explosion or from fire. It is absolutely safe, even in the hands of men with little mechanical training, and the many plants which are in continuous operation, some of them twenty and even twenty-four hours a day, indicate that they are thoroughly reliable and will stand hard, everyday usage. Boiler insurance is unnecessary with producer plants and the troubles and dangers encountered with steam boilers are entirely avoided. The complete gas engine and suction producer plant is almost entirely automatic in operation, very little attention being required. Ordinarily the operator only needs to spend ten to fifteen minutes about every two hours to dump a few buckets of coal into the producer and give general attention to the plant. He can spend part of his time in other useful work and an extra man as fireman is not required, even with plants from 400 to 500 horse power.

Hundreds of thousands of dollars which are now spent annually in building smokestacks can be saved; and what is of greater importance, the smoke nuisance can be entirely abated.

Where the suction gas producer plant uses 1¼ or 1½ pounds of coal, the steam plant commonly requires 4 to 6 pounds, or more. Moreover, with the producer plant there are fewer ashes to be handled and disposed of.

The producer will hold fire all night or even for several days, and the proper quality of gas can be generated after fifteen or twenty minutes blowing to revive the fire. The engine can easily be started on compressed air.

The stand-over loss with the suction producer amounts to about one-third as much as with a steam boiler. In other words, where the stand-over loss with a steam plant for fourteen hours amounts to 600 to 800 pounds, or more, with a suction producer plant of the same horse power this loss would not exceed 200 pounds.

Suction Gas Producers.

A sectional view of a Fairbanks-Morse anthracite suction gas producer is shown in Fig. 4. Coal is admitted to the producer through a hopper at the top. This has double closure, so that the fuel can be introduced without at the same time admitting air. In the process of partial combustion which takes place producer gas is generated. The hot gas passes through a vaporizer in which a small amount of steam is formed, which, with a limited amount of air, passes under the grate of the producer. In

SUCTION GAS PRODUCER POWER

By L. P. Tolman.

It is estimated that there are over 500 producer power plants in this country, having an aggregate of 150,000 horse power. Of these, about eighty-five per cent. are of the "suction" type and fifteen per cent. of the "pressure" type. The suction plants average approximately 100 horse power each, while pressure plants are usually built in sizes larger than 1000 horse power. This article deals with suction gas power plants in single units of 200 horse power, or smaller, and complete plants made up of a number of such units, 1000 horse power, or larger. This range of sizes covers the requirements of the great majority of power users.

Comparative Waste with Steam and Producer Gas Power

Fig. 1 illustrates a modern steam plant with its many complications, including compound condensing steam engine with water tube boiler. This plant converts 8 per cent. of the total energy of the fuel into useful work (in actual practice the percentage utilized is usually less). In other words, 92 per cent. or more of the energy in the coal goes to waste as smoke exhaust from the engine, heat radiation, etc. A 150 horse power steam plant of this type, running at two-thirds load, 3100 hours per year, uses approximately 4½ pounds of coal per brake horse power per hour. With coal at $2.75 per ton, the fuel alone costs $1,118.12 per year. In addition, the cost of attendance is a large item of expense, and the boiler, especially, calls for constant attention, cleaning, and repairs.

The ordinary throttling governor steam engine with tubular boiler, a type which is in very general use, especially in sizes from 15 to 200 horse power, is shown in Fig. 2. This plant converts 5 per cent. (though usually much less) of the total energy of the fuel into useful work. In small steam plants the total amount of energy utilized is often not over 2 or 3 per cent. In other words, 95 per cent. or more of the energy in the coal goes to waste as smoke exhaust from the engine, heat radiation, etc. A 150 horse power steam plant of this type, running at two-thirds load, 3100 hours per year, uses approximately 7 pounds of coal per brake horse power per hour. With coal at $2.75 per ton, the fuel alone costs $2,083.75 per year. In addition, it requires the entire time of at least one man to operate the plant. The boiler, especially, requires constant care, cleaning and repairs, and is always a source of danger.

A suction gas producer power plant is shown in Fig. 3. The apparatus is simple, reliable and very economical. With this plant 18 per cent. of the total energy of the fuel is converted into useful work (varies according to conditions, from 15 to 21½ per cent.). This means that a suction gas producer plant uses from one-half to one-fourth as much coal for a given amount of power as a steam plant. A 150 horse power suction producer plant, running two-thirds load, 3100 hours per year, uses approximately 1½ pounds of coal per brake horse power per hour. (Tests have been made showing a consumption of less than 1¼ pounds at two-thirds load and less than 1 pound at full load.) With anthracite at $5.00 per ton, the fuel alone costs $1,162.50 per year. Furthermore, the cost of attendance can be reduced materially with a producer plant, as the operator can spend part of his time in other useful work.

Much valuable information is given in the report of the United States Geological Survey concerning the fuel testing

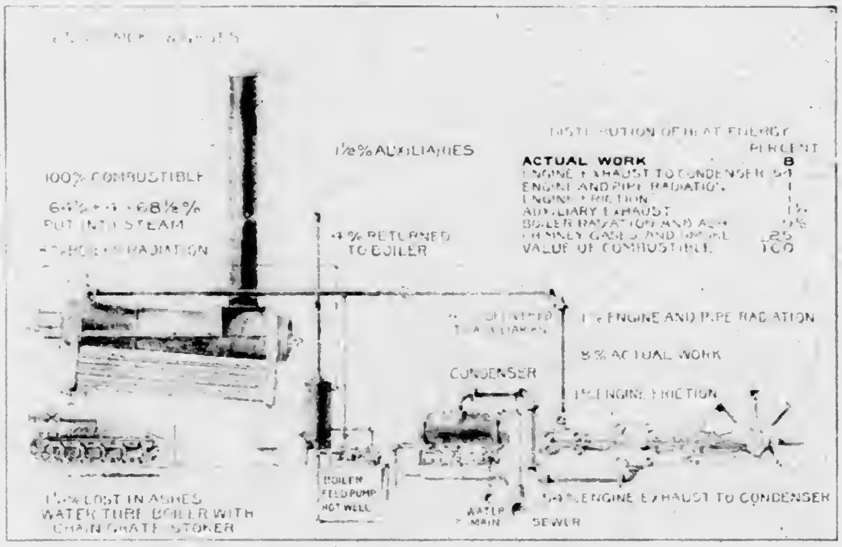


FIG. 1.—COMPOUND CONDENSING STEAM PLANT.

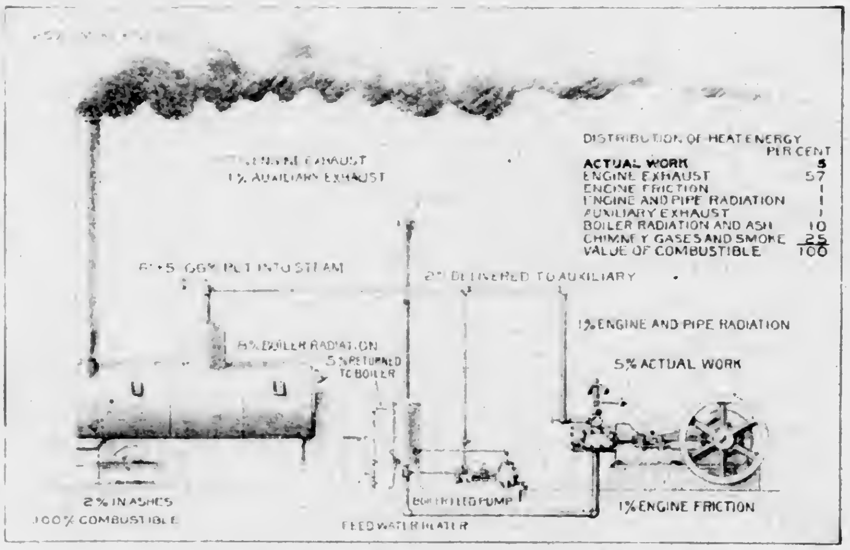


FIG. 2.—SIMPLE STEAM ENGINE AND TUBULAR BOILER.

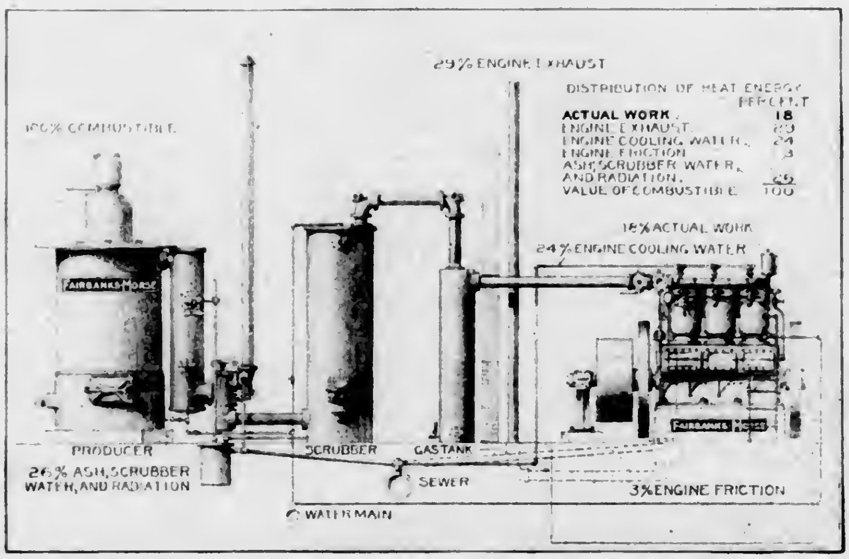


FIG. 3.—SUCTION GAS PRODUCER POWER PLANT.

plant at the Louisiana Purchase Exposition, St. Louis, Mo. For three years the Government experts conducted a series of tests on many samples of coal from mines all over the country. Briefly, the apparatus included a non-condensing Corliss engine steam plant with a water tube boiler and a pressure type producer with a three cylinder vertical gas engine.

From the summary of results obtained from a long series of tests, the fuel consumption in the pressure type producer plant varied from 1.18 to 3.47 pounds per brake horse power per hour, the average being approximately $1\frac{3}{4}$ pounds. The average with the Corliss steam plant was found to be approximately $4\frac{1}{2}$ pounds, using similar fuels. With lignite, the consumption in the pressure producer plant was from 1.95 to 3.47 pounds, the average of five samples actually figuring 2.60 pounds. With the Corliss steam plant using lignite, the average consumption of "coal as fired" (not "dry coal") was approximately 7 pounds.

While most of the above tests were on bituminous coals, which cannot be used advantageously in a suction producer, yet the consumption of anthracite in the latter is usually less than as stated for bituminous coal in the "pressure" type producer; probably due to the fact that there is less resistance to the flow of gas in the suction type. For example, tests on lignite in a suction producer commonly show a consumption of 2 to $2\frac{1}{4}$ pounds, whereas from the five lignite tests at St. Louis the average is 2.60 pounds in a pressure producer plant.

ADVANTAGES OF SUCTION GAS PRODUCER POWER.

We have already discussed the high thermal efficiency of the suction gas producer plant. The most important and the most practical commercial advantage is the economy effected in the cost of developing power. If there were no other advantages, this one feature would be sufficient reason for installing this system. Other advantages may be summed up briefly:

The producer, in which fuel gas is generated from coal, is almost as simple as an ordinary furnace for heating purposes. The gas engine is entirely automatic in operation and needs little more than the ordinary cleaning and care as to lubrication.

There is no danger from explosion or from fire. It is absolutely safe, even in the hands of men with little mechanical training, and the many plants which are in continuous operation, some of them twenty and even twenty-four hours a day, indicate that they are thoroughly reliable and will stand hard, everyday usage. Boiler insurance is unnecessary with producer plants and the troubles and dangers encountered with steam boilers are entirely avoided. The complete gas engine and suction producer plant is almost entirely automatic in operation, very little attention being required. Ordinarily the operator only needs to spend ten to fifteen minutes about every two hours to dump a few buckets of coal into the producer and give general attention to the plant. He can spend part of his time in other useful work and an extra man as fireman is not required, even with plants from 400 to 500 horse power.

Hundreds of thousands of dollars which are now spent annually in building smokestacks can be saved, and what is of greater importance, the smoke nuisance can be entirely abated.

Where the suction gas producer plant uses $1\frac{3}{4}$ or $1\frac{1}{2}$ pounds of coal, the steam plant commonly requires 4 to 6 pounds, or more. Moreover, with the producer plant there are few ashes to be handled and disposed of.

The producer will hold fire all night or even for several days, and the proper quality of gas can be generated after fifteen or twenty minutes blowing to revive the fire. The engine can easily be started on compressed air.

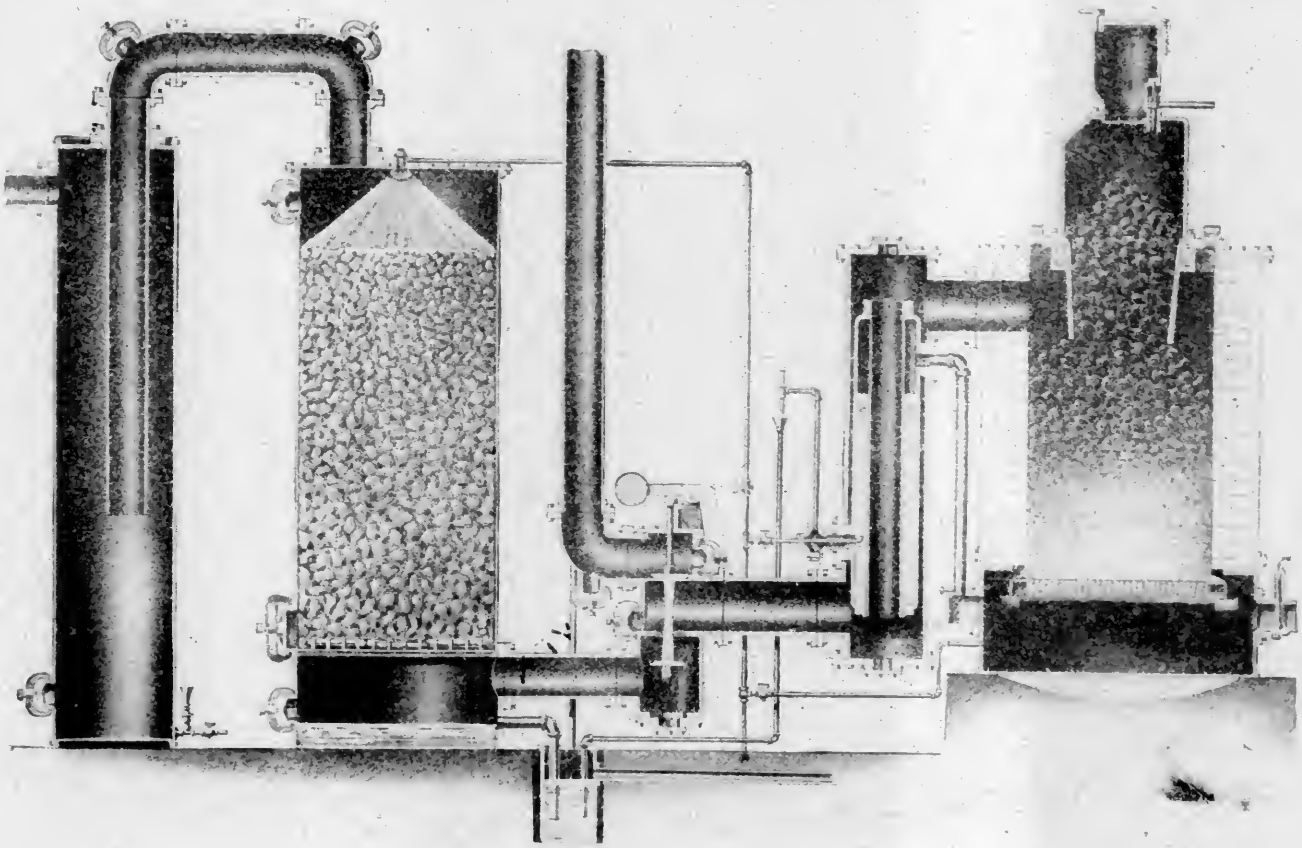


FIG. 4.—SECTIONAL VIEW OF FAIRBANKS-MORSE SUCTION GAS PRODUCER.

The stand over loss with the suction producer amounts to about one-third as much as with a steam boiler. In other words, where the stand over loss with a steam plant for fourteen hours amounts to 600 to 800 pounds, or more, with a suction producer plant of the same horse power this loss would not exceed 200 pounds.

SUCTION GAS PRODUCERS.

A sectional view of a Fairbanks-Morse anthracite suction gas producer is shown in Fig. 4. Coal is admitted to the producer through a hopper at the top. This has double closure, so that the fuel can be introduced without at the same time admitting air. In the process of partial combustion which takes place producer gas is generated. The hot gas passes through a vaporizer in which a small amount of steam is formed, which, with a limited amount of air, passes under the grate of the producer. In

the smaller sizes, the vaporizer is at the top of the producer, where it uses the waste heat from the escaping gas and where at the same time the water keeps the top from getting too hot. In the larger sizes the vaporizer is separate and connected to the producer by piping. From the vaporizer, the hot gas flows through the scrubber, which is merely a cylindrical-shaped tank filled with coke, over which a spray of water is constantly sprinkled. The large contact surface of the coke effectually cleanses the gas of dust and impurities carried over from the producer, and also acts to cool the gas, which is essential in order to prepare it for use in the engine.

With certain fuels, especially when much tar is encountered, it is also necessary to add a sawdust purifier in order to abstract the last traces of tar from the gas. While not absolutely essential, it is always advisable to use a gas tank between the scrubber and the engine, in which a certain amount of gas is stored ready for use in the engine. This is especially desirable

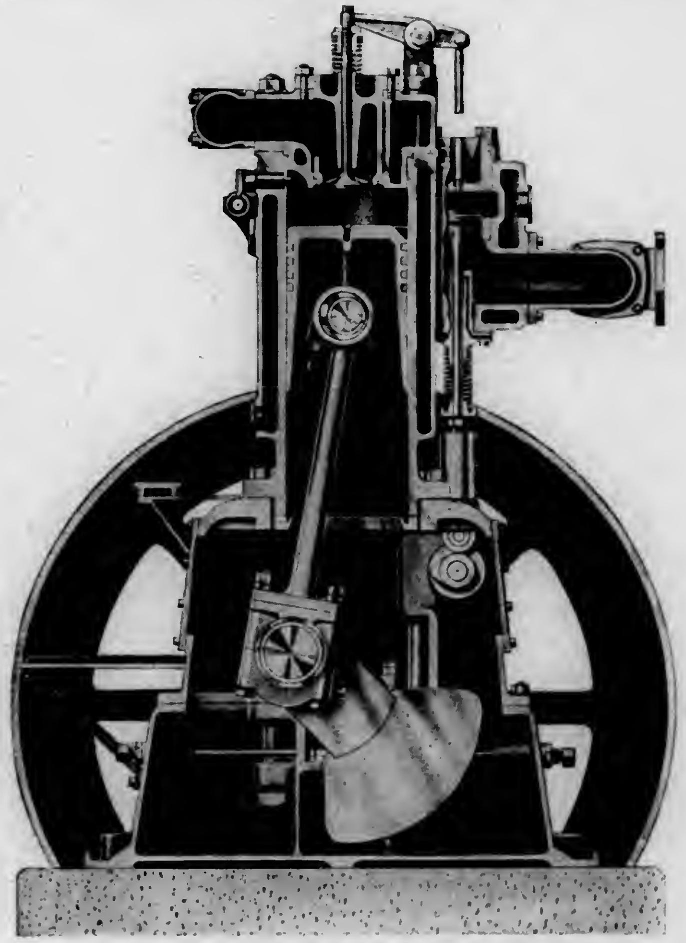


FIG. 5.—SECTIONAL VIEW OF FAIRBANKS-MORSE GAS ENGINE.

where the loads are variable. In the care of the producer, the principal attention needed is to poke the fire every few hours, the length of the interval depending on the quality of the coal, in order to break up and remove clinkers, which would otherwise interfere with the making of sufficient gas. Poke holes are provided so that every part of the fire can be reached conveniently.

Fuels.

Anthracite in "buckwheat" or "pea" sizes, lignite, coke, and charcoal are the fuels commonly used. In many sections the small sizes of anthracite can be bought cheaply in car lots. For example, in Chicago the car-load price of "buckwheat" anthracite is usually about $3.75 per ton. In some of the States west of Chicago the price varies from $5.00 to $7.00 per ton. At some points in southern Canada these small sizes of Pennsylvania anthracite can be bought for from $3.00 to $4.00 per ton. In some of the Eastern States, which are nearer the source of supply, the prices are even less.

The lignite producer offers a wonderfully cheap and reliable power in sections where this fuel is available. There are enormous deposits of lignite in Texas, Arkansas, Louisiana, North Dakota, Montana, Wyoming, Colorado and other Western States. This can usually be had at a price of from $1.00 to $3.00 per ton. Coke and charcoal are economical fuels in some sections and can be used separately or mixed with anthracite.

In order to give some idea of the relative value of different producer fuels, the results of tests on a number of samples are given. These samples were received from various parts of the United States, as well as from foreign countries. For example, in Table 1, giving the analyses of different anthracites, sample 65 is from Europe, 101 and 76 from Pennsylvania, 71 from Elk Mountain, Colo., and 89 from Banff, B. C., Canada. The tests were made by the experimental department at the works of Fairbanks, Morse & Co., Beloit, Wis.:

TABLE 1—ANTHRACITE.

Sample No.	B. T. U. per Lb.	Fixed Carbon	Volatile	Ash	Moisture	Sulphur	Quality
65	15,434	88.8	7.4	2.9	.9	.99	Very Good
101	13,952	83.5	5.5	8.2	2.8	.82	Good
76	12,058	73.9	5.7	18.9	1.5	.86	Poor
71	13,332	77.2	9.3	13.4	.1	.73	Fair
89	14,74[illegible]	79.3	8.1	10.5	2.1	.59	Good

With the best coal there is little formation of clinker that will not work down to the grate without poking from the top, and many European producers have no top poke holes. These are not successful with American coals, for while it is always desirable to get the best coal, it is practical to operate continuously on an average, or even a poor coal, by working the clinkers down through the top poke holes. It is an advantage in using poor anthracite to have large producers.

TABLE 2—COKE.

Sample No.	B. T. U. per Lb.	Fixed Carbon	Volatile	Ash	Moisture	Sulphur	Quality
73	12,787	86.7	2.4	8.4	2.5	.93	Good
77	14,213	92.3	1.7	5.8	.2	.6	Very Good
94	9,528	79.4	3.7	14.3	2.6	.59	Rather Poor
97	13,811	90.4	1.7	6.1	1.8	.55	Very Good

This fuel varies in quality according to the soft coal used in its manufacture and the method of treatment. All coke must be crushed to pass a screen of 1-inch or 1¼-inch mesh, and must be freed from dust with a fine screen. It is usually advisable, where coke is used, to install a one-size larger producer than standard. A sawdust purifier is also desirable to remove the dust, which is more abundant than with anthracite. Gas from coke averages about 115 B.T.U. per cubic foot, while from anthracite it averages 125 or more. For this reason the power capacity of the engine will be a little less on coke gas, but not as much less in proportion as the heating value. Some coke will not maintain the fire hot enough. Mixing one part anthracite with two of coke usually corrects this.

The use of charcoal (14,438 B.T.U. per pound; fixed carbon, 81.3; volatile, 12.9; ash, 1.1), becomes practical by the addition of a centrifugal tar extractor located between the scrubber and a sawdust purifier. With this fuel, also, it is advisable to install a one size larger producer than for anthracite. Charcoal gas has a heating value averaging 130 B.T.U. or more, and because of this gives somewhat more power at the engine. It can be used in as large pieces as will readily go through the producer charging hopper. Less tar results from charcoal that is perfectly charred, but more or less material not perfectly charred is likely to be found. No clinkers are formed with this fuel.

TABLE 3—LIGNITE.

Sample No.	B. T. U. per Lb.	Fixed Carbon.	Volatile	Ash	Moisture	Sulphur
51	11,634	20.3	46.1	6.3	27.3	1.01
57	8,753	29.4	35.7	7.1	27.8	.63
95	11,566	41.8	36.7	3.7	17.8	.41
103	9,765	36.8	35.8	10.7	17.2	4.09

Lignite cannot be used in standard anthracite producers, but the Fairbanks-Morse lignite producer operates very successfully with this fuel. Gas from lignite averages 130 B.T.U. per cubic foot. This fuel can be fed to the producer in any size that will go through the charging hopper, and it causes no serious trouble from clinkers.

Producer Gas Engines—Vertical Type.

These engines are made in sizes of 200 horse power and smaller. By combining several units, plants of 800 to 1,000 horse power or larger have been installed. A section view of the Fairbanks-Morse engine of this type is shown in Fig. 5. It may be of interest to note briefly a few of the carefully developed features in the design of these engines.

The present system of ignition is a great improvement over the methods formerly used. The make-and-break igniter is so constructed that it can be adjusted to spark as early or as late as desired, when the engine is running or at rest, by means of a convenient hand lever. A single lever controls the time of ignition for all cylinders. This is a feature of much importance, especially with producer gas, as it permits timing the ignition to give the greatest possible power and economy with any particular grade of gas, and when the engine is running. In addition, there is an independent adjustment for each igniter which is operated by a drop cam. The igniters can be removed, inspected, and cleaned, without interfering with other working parts. As the successful operation of a gas engine depends largely upon the igniter, the value of these features cannot be emphasized too strongly.

Both valves are mechanically operated from a single cam shaft, which is located inside the crank case. This minimizes the amount of noise, and furthermore the two-to-one reduction of gearing includes a pinion which is made of alternate layers of steel and red fiber. These features insure a quiet running engine.

The simple fly-ball governor is of a carefully designed pattern. It operates a balanced disk valve which is so constructed that there is no frictional contact or surface to become fouled by any impurities in the gas. This is especially important with engines operating on producer gas. The governor insures very close regulation, adapting the engine for electric lighting and other service requiring uniform movement.

Lubrication is effected by means of a single elevated oil reservoir, which is provided with a separate brass pipe with an individual sight feed for each bearing. The drip from the different bearings collects in the base of the engine, which is drained by means of a small pump. The oil is run through a filter and is then used over again.

Each engine is fitted with a hand-operated speed regulator, by means of which the speed can be reduced when the engine is running. One cylinder of each engine is fitted with an automatic compressed air starting gear. This can be thrown into or out of action by the movement of a single lever, and the engine can then be started automatically on compressed air.

Fuel Consumption Tests.

A series of tests have recently been made on a 150 horse power Fairbanks-Morse engine and anthracite producer, for continuous runs of twenty-four hours, at one-quarter load, one-half load, three-quarter load and full load, the object being to determine the comparative economy at different loads. The coal used was an ordinary grade of "buckwheat" Pennsylvania anthracite, running rather high in ash, the analysis being as follows:

Fixed Carbon	78.9%	Moisture	2.7 %
Volatile	5.3%	Sulphur	0.77%
Ash	13.0%	B.T.U. per lb. as fired	13,590

Some of the results of these tests, including the coal consumption per brake horse power hour, are given below:

Load	B. H. P. on Engine	Speed R. P. M.	Coal in 24 Hours	Coal per B. H. P. per Hour	Cooling Water per B. H. P. Hour. Gals.	Steam per Pound of Coal. Lbs.
Full	149.4	224	3838	1.07	5.0	0.48
¾	113.1	226	3185	1.13	5.6	0.45
½	75.4	226	2369	1.3	6.8	0.41
¼	38.	228	1590	1.74	13.1	0.35

Economy tests have often shown a lower consumption than indicated above—frequently less than one pound of coal per brake horse power hour at approximately full load. The figures given are of value as giving the comparative fuel consumption at different loads, and for this purpose they may be considered as conservative and accurate.

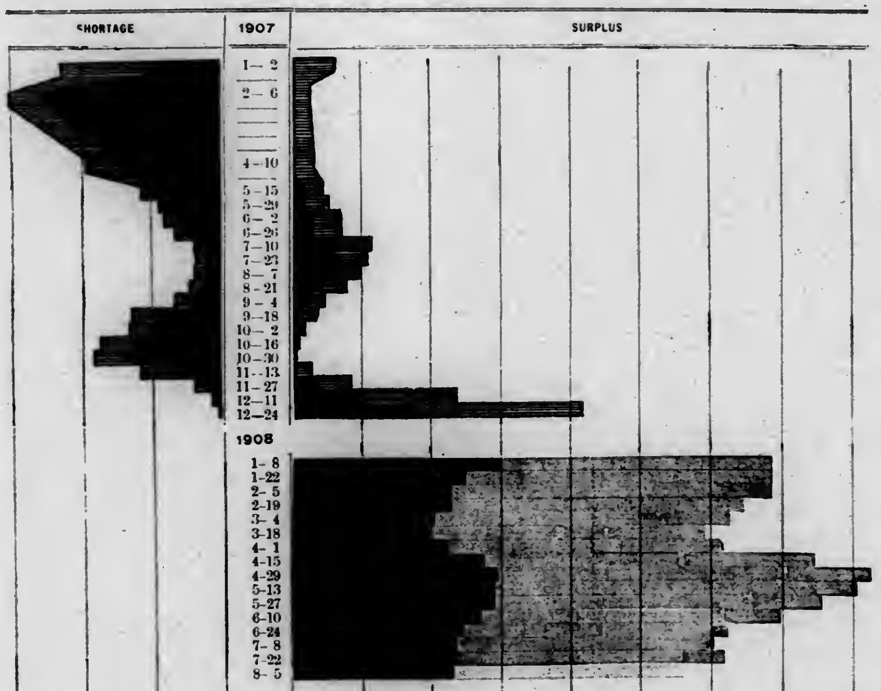


DIAGRAM SHOWING SHORTAGES AND SURPLUSES OF FREIGHT CARS AT FORTNIGHTLY INTERVALS SINCE JANUARY 2, 1907.

THE FREIGHT CAR SITUATION.

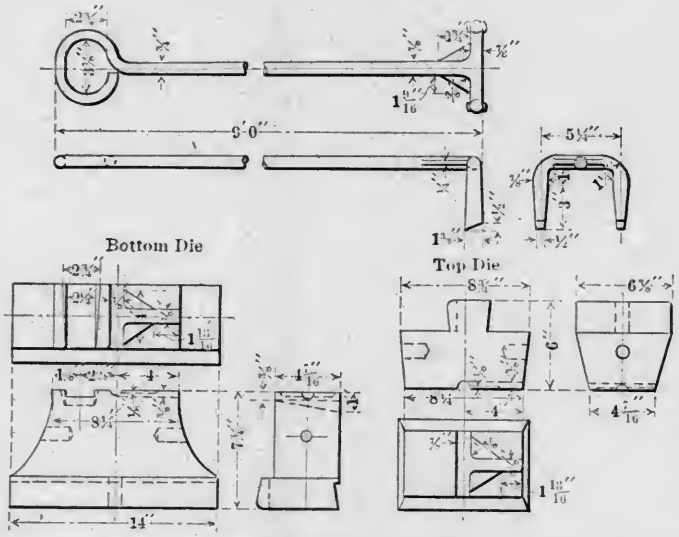
Statistical bulletin No. 29, issued by the committee on car efficiency of The American Railway Association, showed a total of 281,621 surplus cars on August 5, a decrease of 27,059 since the last fortnightly report. Of this decrease 6,505 are box cars, 21,195 coal and gondola, while surplus flat cars increased about 1,000.

Shop reports indicate an increase of about 5,000 in the number of bad order cars, leaving a net improvement of 22,000 cars. The increase in bad order cars is not necessarily an indication of lack of activity in car repairs, but is probably due to the transfer of cars from the available to the shop column on account of defects developing when cars are taken from storage tracks for restoration to service.

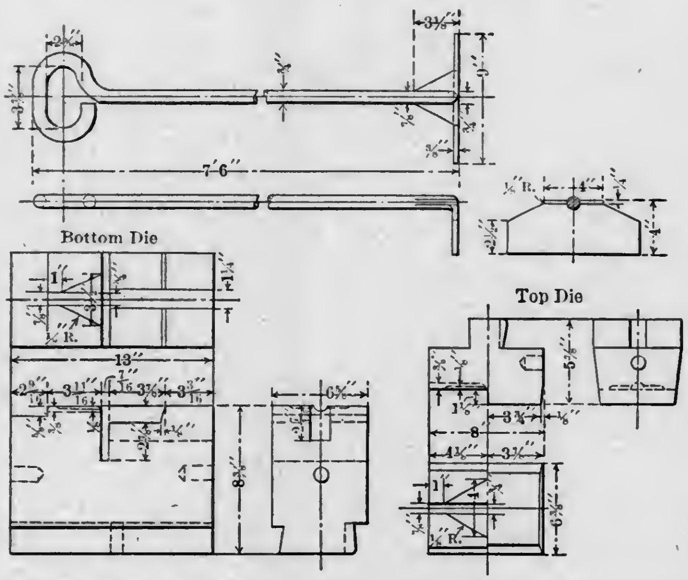
The accompanying chart shows graphically the surpluses and shortages as taken from the fortnightly reports since January 2, 1907. The black parts represent box cars and the shaded portions other types of freight cars.

IMPROVED DESIGNS OF FIRE HOOK AND ASH SCRAPER.

The ordinary types of fire hooks and ash scrapers are weak at the junction of the scraper, or hook, and the handle and are frequently consigned to the scrap pile after two or three trips over the road. The drawings show improved designs of a fire hook and an ash scraper, together with the hammer dies for making them, as designed by A. W. McCaslin, foreman blacksmith of the Pittsburgh & Lake Erie Railroad at the McKees Rocks shops. These tools are made with a web at the junction of the handle and the hook, or scraper, making them practically unbreakable at that point under ordinary usage. In making the scrapers, that portion constituting the scraper blade and the web



IMPROVED FIRE HOOK AND HAMMER DIES FOR ITS MANUFACTURE.



IMPROVED ASH SCRAPER AND HAMMER DIES FOR ITS MANUFACTURE.

is punched to shape, from a 3/8 in. iron or steel plate, at one blow of the steam hammer. The web is then bent over at right angles and is ready to be welded to the handle. These two operations cost about one cent.

The eye is bent on the handle rod and the other end of the rod is upset to 1 in. in diameter, 3 in. long, on a small pneumatic bulldozer, these two operations costing less than one cent. The blade is then welded to the handle by means of the steam hammer dies shown. When at a welding heat the blade is dropped in the groove that is cut crosswise of the bottom die, the handle is placed on the top side of the web and two or three blows of the hammer make the weld and form the web. The first hooks were made so that the handle bent down over the back of the scraper, making a heavy half round brace at the bend, but this extra strength was not required and the practice was discontinued. The fire hook is made in a somewhat similar manner, the dies being shown in detail on the drawing.

OXY-ACETYLENE PROCESS FOR WELDING AND CUTTING.

A paper entitled "History and Status of the Oxy-Acetylene Process in America" was presented by Augustine Davis at the recent meeting of the International Acetylene Association in Chicago. Parts of this paper, referring to the field of usefulness of the oxy-acetylene process, its present status, and giving approximate figures as to the cost of welding and cutting steel by this process, are reproduced as follows:

Autogenous welding is the uniting of metals by heat, without either flux or compression. While this object has been obtained, to some extent, by the use of oxy-gas and oxy-hydrogen, it is only very recently that a really satisfactory method has been developed through the oxy-acetylene process. It is obvious that very high temperature, full control and facility of application are necessary requisites for great efficiency.

The highest temperature of the best solid fuel furnaces is about 3,000 F. The oxy-hydrogen, which was the hottest of the gas flames, is something less than 4,000 F. The oxy-acetylene flame jumps this temperature more than 2,000 F. to about 6,300 F., being more than double the hottest solid fuel heat known. As acetylene produces about five times more heat per cubic foot than hydrogen, and nearly doubles it in intensity, a marvelously powerful flame is condensed into very small volume. Compared to the oxy-hydrogen flame, it is like a finely-pointed tool to a blunt instrument. With such a tool, having heating power from two to three times that required to melt the commercial metals, almost incredible results are obtained.

By this process iron, steel, cast iron, aluminum, brass, copper and other metals can be so perfectly united that when smooth the joint cannot be discerned. Containers for fluids and liquids can be made without joints, and will not leak when bruised or dented, as will riveted vessels. Blow-holes and other defects in iron, steel, brass and other castings can be repaired, not only saving the castings, but many times expensive machine work as well. Quickly repairing broken machines, boilers and steam and other piping in place is one of the most valuable features of this process, not only saving the articles themselves, but what is often of vastly more importance, preventing long and expensive suspension of operations, while repairs are being made. Worn parts of machinery and teeth on gear wheels can be built up; tool steel added to common steel; dies repaired, and numberless other operations accomplished which are not possible by other methods. The repair of aluminum automobile casings, and cast iron cylinders is a large business in itself. Not only can metal of the same kind be united, but those of different kinds can be perfectly united.

The facility with which steel and iron (except cast iron) can be cut is really marvelous. The operation is performed by heating the metal at the first point of contact to the red by the ordinary welding flame, and with this flame continued, a jet of pure oxygen is turned on which unites with the carbon of the metal and disintegrates it with surprising rapidity. The cut is narrow and smooth, with no material injury by oxidation. The cut can be made in any shape, and the process will be found very useful in cutting irregular forms, and will be valuable, especially in making many kinds of dies and in fitting steel plates. It is very effective for cutting steel beams in structural work.

The A. Boas, Rodrigues & Co. torch, known here as the Davis-Bournonville, has been improved in design and construction until it is now practically perfect. All of the authorities have given 2.5 parts of oxygen to 1 of acetylene, as the theoretical quantities required, and 1.8 of oxygen to 1 of acetylene, as the quantities actually used in practice. With their apparatus and torch the Davis-Bournonville Co. has succeeded in securing a perfect welding flame, with only 1.28 parts of oxygen to 1 of acetylene,

APROXIMATE COST OF OXY-ACETYLENE WELDING.

Oxygen at three cents—Acetylene at one cent per cubic foot. Labor 30 cents per hour.

Tip Number	Thickness of Metal	Consumption of Acetylene Per Hour	Consumption of Oxygen Per Hour	Proper Pressure in Pounds for Oxygen	Lineal Feet Welded Per Hour	Cost of Labor Per Hour	Total Cost Per Hour	Cost Per Lineal Foot
1	$\frac{1}{32}$ to $\frac{1}{16}$	2.8 feet	3.6 feet	8 to 10 lbs.	50 feet	.30 cents	.436	.0087
2	$\frac{1}{16}$ to $\frac{3}{32}$	4.5 "	5.7	10 to 12 "	30 "	30 "	.516	.0172
3	$\frac{3}{32}$ to $\frac{1}{8}$	7.5 "	9.7 "	12 to 14 "	25 "	30 "	.666	.0266
4	$\frac{1}{8}$ to $\frac{1}{4}$	11.7 "	15. "	14 to 18 "	16 "	.30 "	.867	.054
5	$\frac{1}{4}$ to $\frac{5}{16}$	18. "	23. "	18 to 22 "	10 "	.30 "	1.17	.117
6	$\frac{5}{16}$ to $\frac{7}{16}$	25. "	32. "	20 to 25 "	7 "	.30 "	1.51	.216
7	$\frac{7}{16}$ to $\frac{1}{2}$	32.5 "	41.5 "	22 to 27 "	5 "	.30 "	1.87	.374
8	$\frac{1}{2}$ upward	48.5 "	62. "	24 to 30 "			2.64	

APPROXIMATE COST OF CUTTING STEEL.

Number Cutting Tip	Use Welding Tip No.	Thickness of Steel	Heating Jet. Feet of Acetylene	Heating Jet. Feet of Oxygen	Cutting Jet. Feet of Oxygen	Pressure of Oxygen Heating Jet	Pressure of Oxygen Cutting Jet	Lineal Feet Cut Per Hour	Labor Per Hour	Total Cost Per Hour	Cost Per Lineal Foot
1	4	up to ½"	12	15½	60	14 to 18 lbs.	125 lbs.	60	.30	2.68	.0447
2	4	½" to 1½"	12	15½	75	14 to 18 "	125 to 150	50	.30	3.13	.0627
3	5	1½" up	18	23	75	18 to 22 "	150 to 175	40	.30	4.02	.1005

not only effecting a very material saving in the cost of operation, but obtaining better results as well. An imperfect mixture of gases is not only much more expensive, but an excess of oxygen oxidizes the metal, and too much acetylene carburets it, either condition being seriously detrimental.

Railway companies are particularly interested. At one of the large railway shops, several repairs to locomotive boilers have been made, obviating the expensive removal of defective sheets. An extensive demonstration is being made at this shop, the results of which are being awaited by several other railway companies with much interest. Recently about twenty split boiler tubes were welded by this process, all of which were then burst by excessive pressure, but not one of them parted at the weld. Some months since, J. G. Stevenson, of the Baltimore & Ohio Railway Co., made some tests and obtained 94 per cent. of the original strength of cast steel and 88 per cent. of rolled steel. The experience in operation since has undoubtedly improved this kind of work.

In the railway shops, where these tests are being made, thermit is successfully used in welding heavy locomotive frames, but it is believed that the oxy-acetylene process can be used to great advantage in preparing the frames for the operation, and in cutting away the excess of very hard material afterwards. Recently about 70 feet of steel piling, running from ⅜ in. to 2¼ ins. in thickness, and a number of steel beams were cut in the construction of a building in New York. A 15-in. I-beam was cut in four minutes. Cast iron welded by this process rarely breaks in the weld. Cast iron welded to steel breaks in the original cast iron instead of where joined to the steel.

The development of this process is scarcely begun, and its field is almost without limit, but as previously stated, it is an art which will require intelligence, fertility, patience and experience to secure the marvelous results of which it is capable. Pure oxygen and acetylene and the best apparatus possible to produce them are absolute requisites. Short cuts, cheap apparatus and incapable operators are certain to retard progress greatly. Where the process is to be used over and over on the same kind of work, a conscientious operator of very ordinary ability, can, within a few weeks, become quite expert, but where a very large variety of work is to be performed, knowledge of metals, resourcefulness, personal interest and experience are indispensable.

A carefully prepared table, showing the approximate cost of cutting and welding is appended hereto, and will be found of much interest to investigators.

IMPROVED ROLLER BEARING.

A new Grant roller bearing has recently been produced by the Standard Roller Bearing Company of Philadelphia. The new bearing has conical or tapered rollers, but they are solid. The

IMPROVED GRANT ROLLER BEARING.

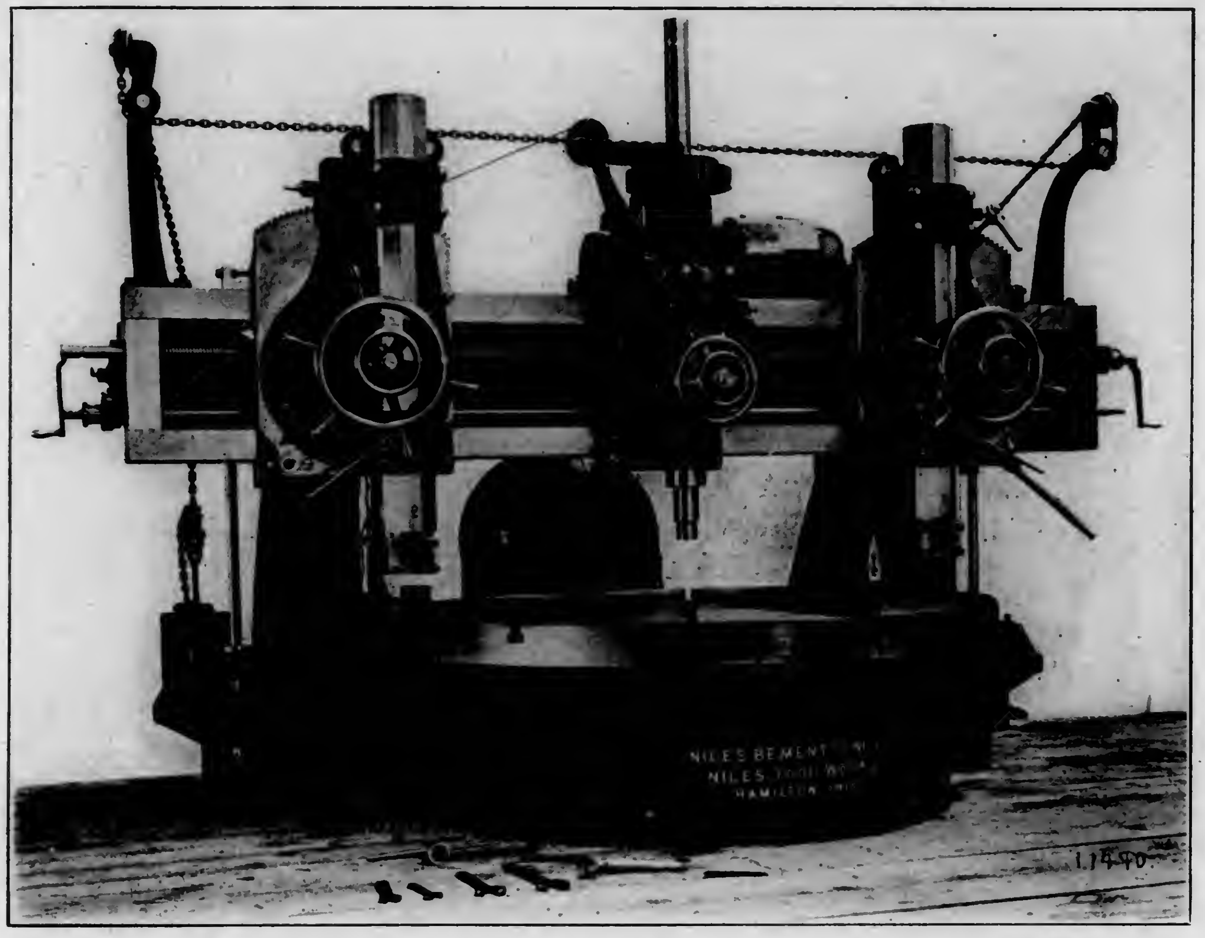
races and cones are made of special steel, with the temper drawn, so that they are very tough and will not chip or break under the most severe service.

The cage or retainer holding the rolls is made of the same general type as that used so successfully by the company for many years on its standard journal roller bearing; it consists of individual sockets or races, in which the ends of the rolls rest, and is made of solid steel with the two ends securely riveted together by a special electric riveter, giving the strongest form of cage or retainer that can be devised; the hot riveting makes the cage substantially solid or one-piece; it is impossible for it to twist or get out of shape, and, as there are no small journals or pins on the rollers, it makes an exceedingly strong bearing.

The cone has an especially wide shoulder, against which the ends of the rollers have a bearing, practically to the center of the roll, the shoulder having the same degree of bevel as the ends of the rolls. The entire thrust is taken in this manner, giving great durability and strength to the bearing.

The bearing is made interchangeable with other forms of conical or tapered roller bearings and its construction is such that it will carry a heavier overload than usual.

American Street and Interurban Railway Association.—The annual meeting of this association will be held at Atlantic City, October 12-16. The secretary is B. V. Swenson, 29 West Thirty-ninth Street, New York City.



TIRE BORING MILL SIMILAR TO ONE USED AT C. & N. RY. SHOPS, EXCEPT THAT IT HAS A CENTER BORING HEAD.

RAPID TIRE BORING.

CHICAGO & NORTHWESTERN RAILWAY.

The Chicago & Northwestern Railway some time ago installed in its Chicago shops a boring mill which is specially adapted for boring driving wheel tires and is not used for any other purpose. Fifty-four 56-in. tires have been bored on this machine in eight hours and fifty-seven minutes. The roughing and finishing cuts were taken at the same time, the cutting speed being at the rate of 30 ft. per minute. The feed was at the rate of ½ in. per turn of the table and the amount of stock removed varied from 1/16 to 3/16 in. on the radius. Two swinging jib cranes, with air hoists, serve the machine and the machinist was assisted by two helpers when the above record was made. When the machine was first installed it was served by one crane only and the best record which it was possible to make under these conditions was forty-one 56-in. tires in nine hours, or thirteen less than was possible after the second crane was installed.

The machine was furnished by the Niles-Bement-Pond Company, and is similar to the one shown in the photograph, except that it is not equipped with the center boring head. It has a stationary cross rail and two heads, and is equipped with a four jaw universal chuck which is used for centering the tires only, special holding clamps being used which are inserted in the T slots between the universal jaw slots. These were designed by Oscar Otto, the general foreman. The table is supported by a wide track just inside the main driving gear. A large spindle attached to the center of the table extends down a considerable distance below the base of the mill, furnishing a rigid support to the table for withstanding the heavy cuts. Sixteen feeds of the positive gear type are provided.

The mill is driven by a General Electric 25 h.p. motor with a 2 to 1 speed variation, operated on a 220 volt direct current circuit. The motor is geared direct to the speed box, which mechanically furnishes four changes of speed. From the speed box power is transmitted through a pair of bevel gears to a vertical shaft carrying a pinion which engages with an external gear, nearly the full size of the table.

VARIATIONS IN AVERAGE PRICES.

The variations during the eighteen years since 1890 are summarized in a table just issued by the Bureau of Commerce and Labor. The average price from 1890 to 1899 is taken as 100. The average is made up from the wholesale prices of 258 staple

Year.	Relative price of all commodities.	Year.	Relative price of all commodities.
1890	112.9	1899	101.7
1891	111.7	1900	110.5
1892	106.1	1901	108.5
1893	105.6	1902	112.9
1894	96.1	1903	113.6
1895	93.6	1904	113.0
1896	90.4	1905	115.9
1897	89.7	1906	122.5
1898	93.4	1907	129.5

articles and the figures may be taken as representing the variation in the cost of living or the changing value of the gold dollar, since the value of a dollar is really measured by the amount of goods it will purchase.—*Engineering News.*

THE TOTAL PANAMA CANAL EXCAVATION since the American Government took possession in May, 1904, to the end of the fiscal year, June 30, 1908, totals 40,938,575 cu. yd., this figure including the earth moved from the canal prism and from the accessory works. Of this amount 27,979,375 cu. yd., or about 66 per cent. of the total, has been taken out in the last fiscal year, as against 8,623,052 cu. yd. during the preceding year, and 3,423,021 cu. yd. during the year ending with June, 1906. The records of last year show that the steam shovels removed 17,457,161 cu. yd., the dredges 10,399,417 cu. yd. and that 122,797 cu. yd. were handled by other methods. In the Culebra cut the steam shovels excavated 12,005,360 cu. yd., and 59,778 cu. yd. were taken out by other means.

NEWTON SPECIAL CYLINDER AND VALVE CHAMBER BORING MACHINE.

CYLINDER AND VALVE CHAMBER BORING MACHINE.

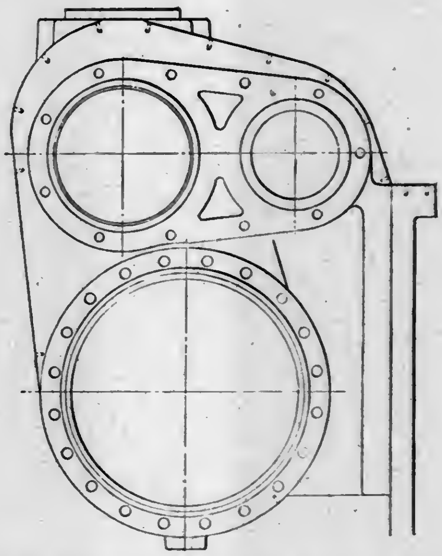
The accompanying illustration shows a special cylinder boring machine, designed by the Newton Machine Tool Works, Inc., Philadelphia, for boring any class of simple or compound engine cylinders and piston valve chambers at one setting. It is said that a simple cylinder and valve chamber can be bored in five hours. Where inclined cylinders are used an auxiliary table may be furnished which can be swiveled to bore at an angle of 20 degrees.

After a cylinder has been planed it is placed on parallel strips on the table of the boring machine, and by means of the vertical, transverse and longitudinal adjustments the high and low pressure cylinders and valve chamber of a compound locomotive may be bored at one setting. This insures the alignment of the cylinders, and by the use of gauges the proper distance between centers may be maintained. A typical example of the work which may be accomplished in this way is illustrated by the sketch.

The spindle has a speed range of from 4 to 15 r.p.m. and may be driven by either a four step cone pulley belt drive or a 20 h.p., 3 to 1 variable speed motor. The drive is connected to the spindle through a clutch, so that the spindle may be started or stopped without stopping the motor or countershaft. The motor is fitted with a fly wheel to overcome the shock of engaging the clutch. The spindle is 7 in. in diameter and is fitted with two splines for driving. It is ground and fitted in sleeves, one in each bearing. The sleeve in the main pedestal drives the spindle through a phosphor bronze worm wheel, 41 in. in diameter, and a hardened steel worm with a roller thrust bearing; the worm and worm wheel are encased and run in oil. The other sleeve is in the foot-stock or outboard bearing and is keyed to the spindle and revolves with it. Both of these sleeves are lapped in the hole for the spindle so as to insure a proper bearing, and are ground on the outside and fitted in brass bushings which are accurately scraped, a cap bearing being provided for compensating for wear.

To each of these sleeves is fitted a special design of facing arm, which can be engaged or disengaged without stopping the spindle motion; on each facing arm is fitted a tool slide, with in and out adjustment for setting the depth of cut; the tool slide has a feed in either direction on the arm, by means of star wheel and pins. The spindle is fed forward by a trolley or carriage, operated by a screw and nut, and has a continuous motion of 140 in. so that it can be entirely withdrawn for removing cylinders at a single transverse motion. The outboard, or foot-stock, bearing is adjustable by means of a rack and pinion to give a minimum distance between the facing arms of 45 in. and a maximum distance of 60 in.

The cross adjusting table is fitted with steel plates on the top, which gives a steel web to the T-slots and prevents the edges from breaking out; it also maintains the alignment of the top of the table. The table has both hand and power adjustment and is adjustable longitudinally on the knee in order to bring different lengths of cylinders central between the facing arms. The knee is accurately fitted between the bed, and is supported by four screws, 6 in. in diameter, which are used to raise and lower the table, and properly support it to give a minimum distance from center of spindle to top of table of 43 in. and a

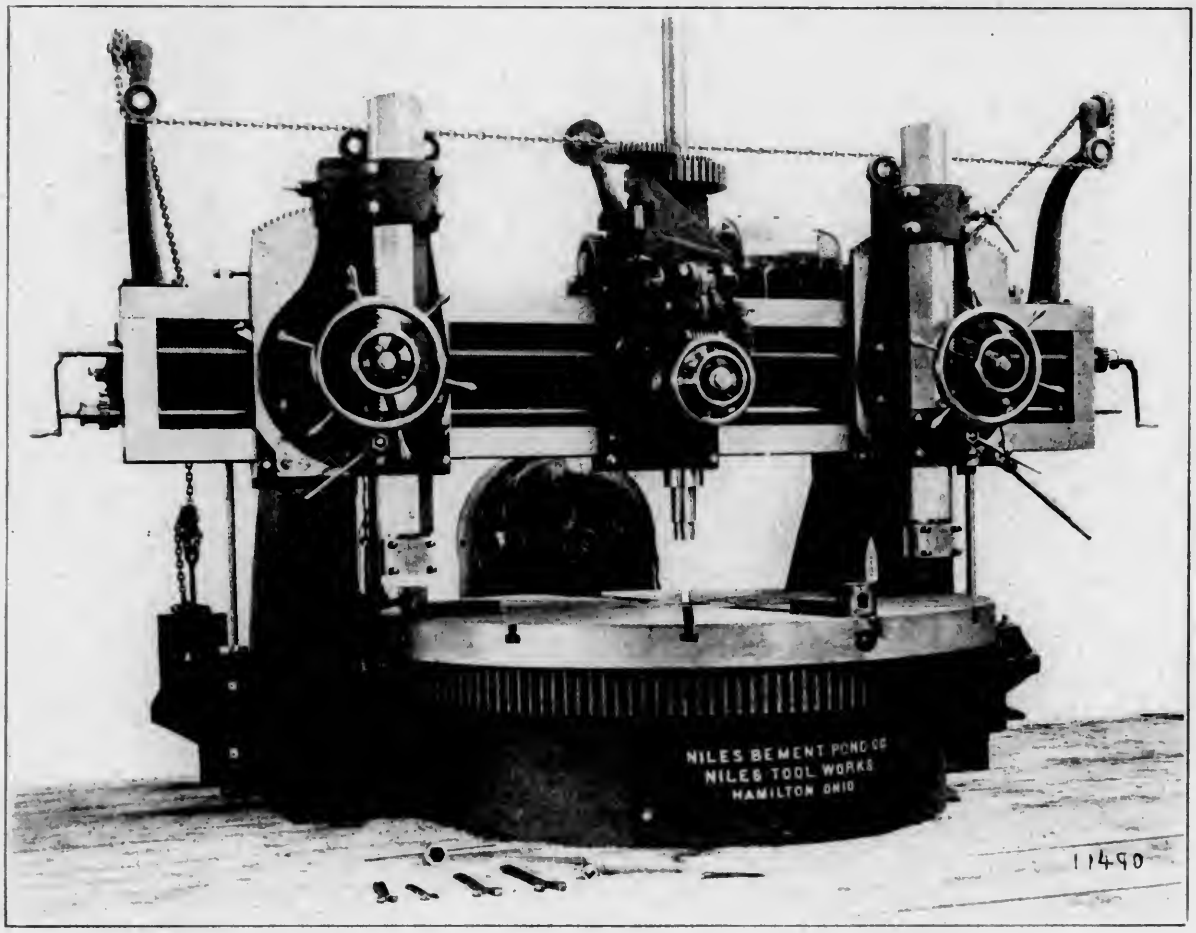


ILLUSTRATING WORK WHICH MAY BE BORED AT ONE SETTING.

maximum distance of 51 in. The table is raised and lowered by power with a fine hand adjustment.

Six changes of feed in either direction are supplied to the spindle through the gear box, the feeds amounting to 0.062, 0.100, 0.166, 0.333, 0.667 and 1 inch per revolution of spindle. The feed is engaged by the lever above the feed box, which when moved to the left engages the feed, and when moved to the right engages the quick traverse, both of these movements being reversed by the lever directly under the hand-wheel in front of the machine. The quick power motion in either direction is at the rate of 10 feet per minute.

NATIONAL MACHINE TOOL BUILDERS' ASSOCIATION.—The regular annual meeting of this association will take place, October 20 and 21, in New York City. The headquarters will be at the Hotel Imperial, Broadway and Thirty-second street.



TIRE BORING MILL SIMILAR TO ONE USED AT C. & N. W. RY. SHOPS, EXCEPT THAT IT HAS A CENTER BORING HEAD.

RAPID TIRE BORING.

CHICAGO & NORTHWESTERN RAILWAY.

The Chicago & Northwestern Railway some time ago installed in its Chicago shops a boring mill which is specially adapted for boring driving wheel tires and is not used for any other purpose. Fifty four 56 in. tires have been bored on this machine in eight hours and fifty seven minutes. The roughing and finishing cuts were taken at the same time, the cutting speed being at the rate of 30 ft. per minute. The feed was at the rate of 1/2 in. per turn of the table and the amount of stock removed varied from 1/16 to 3/16 in. on the radius. Two swinging jib cranes, with air hoists, serve the machine and the machinist was assisted by two helpers when the above record was made. When the machine was first installed it was served by one crane only and the best record which it was possible to make under these conditions was forty one 56 in. tires in nine hours, or thirteen less than was possible after the second crane was installed.

The machine was furnished by the Niles Bement Pond Company, and is similar to the one shown in the photograph, except that it is not equipped with the center boring head. It has a stationary cross rail and two heads, and is equipped with a four jaw universal chuck which is used for centering the tires only, special holding clamps being used which are inserted in the T slots between the universal jaw slots. These were designed by Oscar Otto, the general foreman. The table is supported by a wide track just inside the main driving gear. A large spindle attached to the center of the table extends down a considerable distance below the base of the mill, furnishing a rigid support to the table for withstanding the heavy cuts. Sixteen feeds of the positive gear type are provided.

The mill is driven by a General Electric 25 h.p. motor with a 2 to 1 speed variation, operated on a 220 volt direct current circuit. The motor is geared direct to the speed box, which mechanically furnishes four changes of speed. From the speed box power is transmitted through a pair of bevel gears to a vertical shaft carrying a pinion which engages with an external gear, nearly the full size of the table.

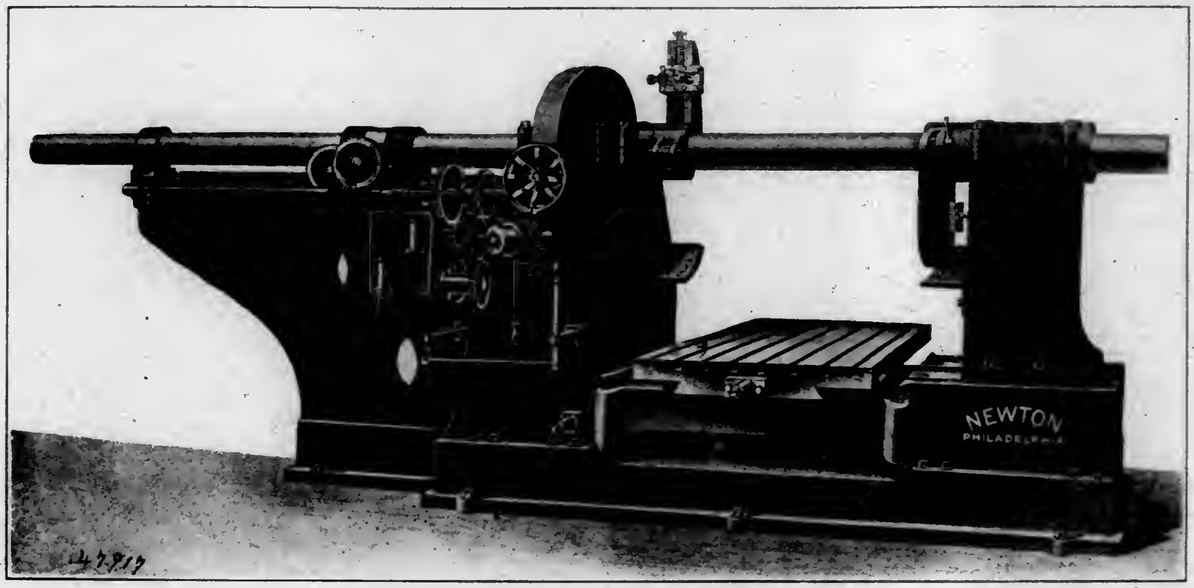
VARIATIONS IN AVERAGE PRICES.

The variations during the eighteen years since 1890 are summarized in a table just issued by the Bureau of Commerce and Labor. The average price from 1890 to 1899 is taken as 100. The average is made up from the wholesale prices of 258 staple

Year.	Relative price of all commodities.	Year.	Relative price of all commodities.
1890	112.9	1899	101.7
1891	111.7	1900	110.5
1892	106.1	1901	108.5
1893	105.6	1902	112.9
1894	96.1	1903	113.6
1895	93.6	1904	113.0
1896	90.4	1905	115.9
1897	89.7	1906	122.5
1898	93.4	1907	129.5

articles and the figures may be taken as representing the variation in the cost of living or the changing value of the gold dollar, since the value of a dollar is really measured by the amount of goods it will purchase.—*Engineering News.*

THE TOTAL PANAMA CANAL EXCAVATION since the American Government took possession in May, 1904, to the end of the fiscal year, June 30, 1908, totals 41,038,575 cu. yd., this figure including the earth moved from the canal prism and from the accessory works. Of this amount 27,070,375 cu. yd., or about 66 per cent of the total, has been taken out in the last fiscal year, as against 8,023,052 cu. yd. during the preceding year, and 3,423,021 cu. yd during the year ending with June, 1906. The records of last year show that the steam shovels removed 17,457,161 cu. yd., the dredges 10,309,417 cu. yd. and that 122,707 cu. yd. were handled by other methods. In the Culebra cut the steam shovels excavated 12,005,360 cu. yd., and 50,778 cu. yd. were taken out by other means.



NEWTON SPECIAL CYLINDER AND VALVE CHAMBER BORING MACHINE.

CYLINDER AND VALVE CHAMBER BORING MACHINE.

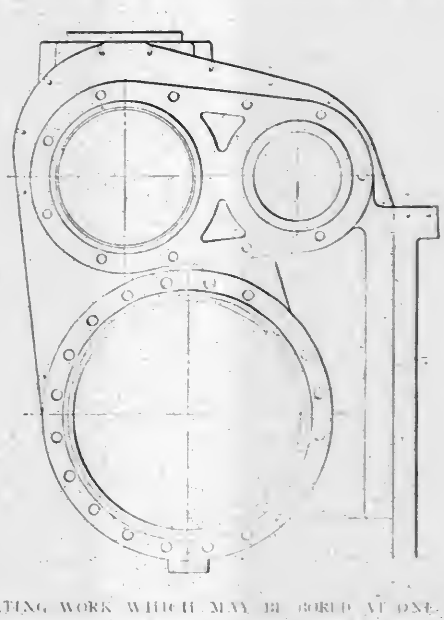
The accompanying illustration shows a special cylinder boring machine, designed by the Newton Machine Tool Works, Inc., Philadelphia, for boring any class of simple or compound engine cylinders and piston valve chambers at one setting. It is said that a simple cylinder and valve chamber can be bored in five hours. Where inclined cylinders are used an auxiliary table may be furnished which can be swiveled to bore at an angle of 20 degrees.

After a cylinder has been planed it is placed on parallel strips on the table of the boring machine, and by means of the vertical, transverse and longitudinal adjustments the high and low pressure cylinders and valve chamber of a compound locomotive may be bored at one setting. This insures the alignment of the cylinders, and by the use of gauges the proper distance between centers may be maintained. A typical example of the work which may be accomplished in this way is illustrated by the sketch.

The spindle has a speed range of from 4 to 15 r.p.m. and may be driven by either a four step cone pulley belt drive or a 20 h.p., 3 to 1 variable speed motor. The drive is connected to the spindle through a clutch, so that the spindle may be started or stopped without stopping the motor or countershaft. The motor is fitted with a fly wheel to overcome the shock of engaging the clutch. The spindle is 7 in. in diameter and is fitted with two splines for driving. It is ground and fitted in sleeves, one in each bearing. The sleeve in the main pedestal drives the spindle through a phosphor bronze worm wheel, 41 in. in diameter, and a hardened steel worm with a roller thrust bearing; the worm and worm wheel are encased and run in oil. The other sleeve is in the foot-stock or outboard bearing and is keyed to the spindle and revolves with it. Both of these sleeves are lapped in the hole for the spindle so as to insure a proper bearing, and are ground on the outside and fitted in brass bushings which are accurately scraped, a cap bearing being provided for compensating for wear.

To each of these sleeves is fitted a special design of facing arm, which can be engaged or disengaged without stopping the spindle motion; on each facing arm is fitted a tool slide, with in and out adjustment for setting the depth of cut; the tool slide has a feed in either direction on the arm, by means of star wheel and pins. The spindle is fed forward by a trolley or carriage, operated by a screw and nut, and has a continuous motion of 140 in. so that it can be entirely withdrawn for removing cylinders at a single transverse motion. The outboard, or foot-stock, bearing is adjustable by means of a rack and pinion to give a minimum distance between the facing arms of 45 in. and a maximum distance of 60 in.

The cross adjusting table is fitted with steel plates on the top, which gives a steel web to the T-slots and prevents the edges from breaking out; it also maintains the alignment of the top of the table. The table has both hand and power adjustment and is adjustable longitudinally on the knee in order to bring different lengths of cylinders central between the facing arms. The knee is accurately fitted between the bed, and is supported by four screws, 6 in. in diameter, which are used to raise and lower the table, and properly support it to give a minimum distance from center of spindle to top of table of 43 in. and a

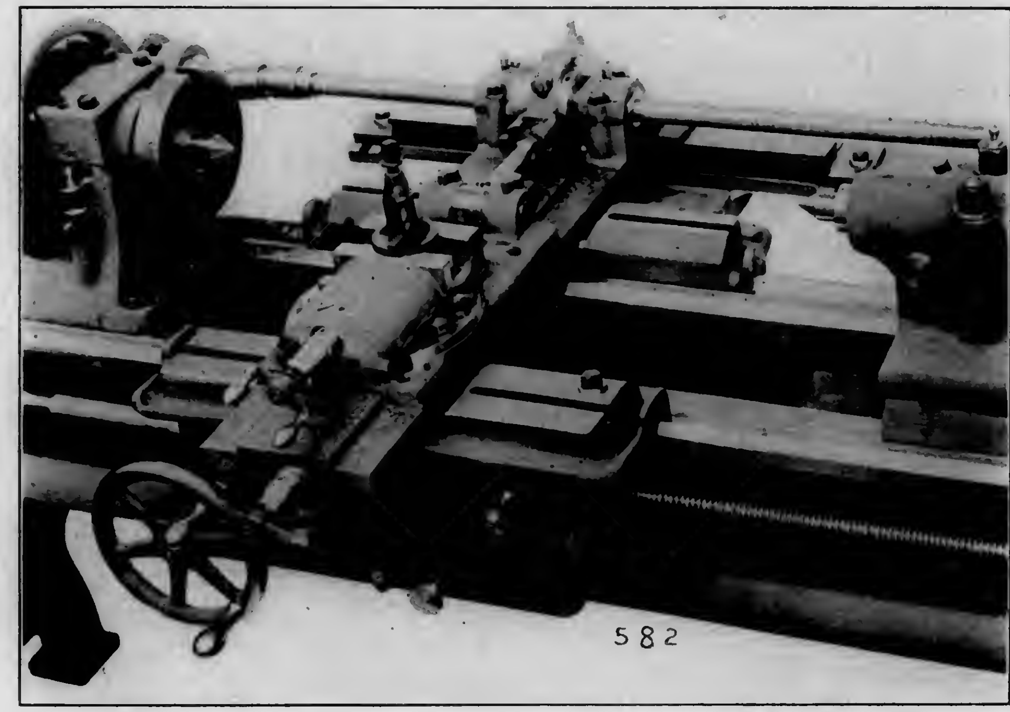


ILLUSTRATING WORK WHICH MAY BE BORED AT ONE SETTING.

maximum distance of 51 in. The table is raised and lowered by power with a fine hand adjustment.

Six changes of feed in either direction are supplied to the spindle through the gear box, the feeds amounting to 0.062, 0.100, 0.166, 0.333, 0.667 and 1 inch per revolution of spindle. The feed is engaged by the lever above the feed box, which when moved to the left engages the feed, and when moved to the right engages the quick traverse, both of these movements being reversed by the lever directly under the hand wheel in front of the machine. The quick power motion in either direction is at the rate of 10 feet per minute.

NATIONAL MACHINE TOOL BUILDERS' ASSOCIATION.—The regular annual meeting of this association will take place, October 20 and 21, in New York City. The headquarters will be at the Hotel Imperial, Broadway and Thirty-second street.



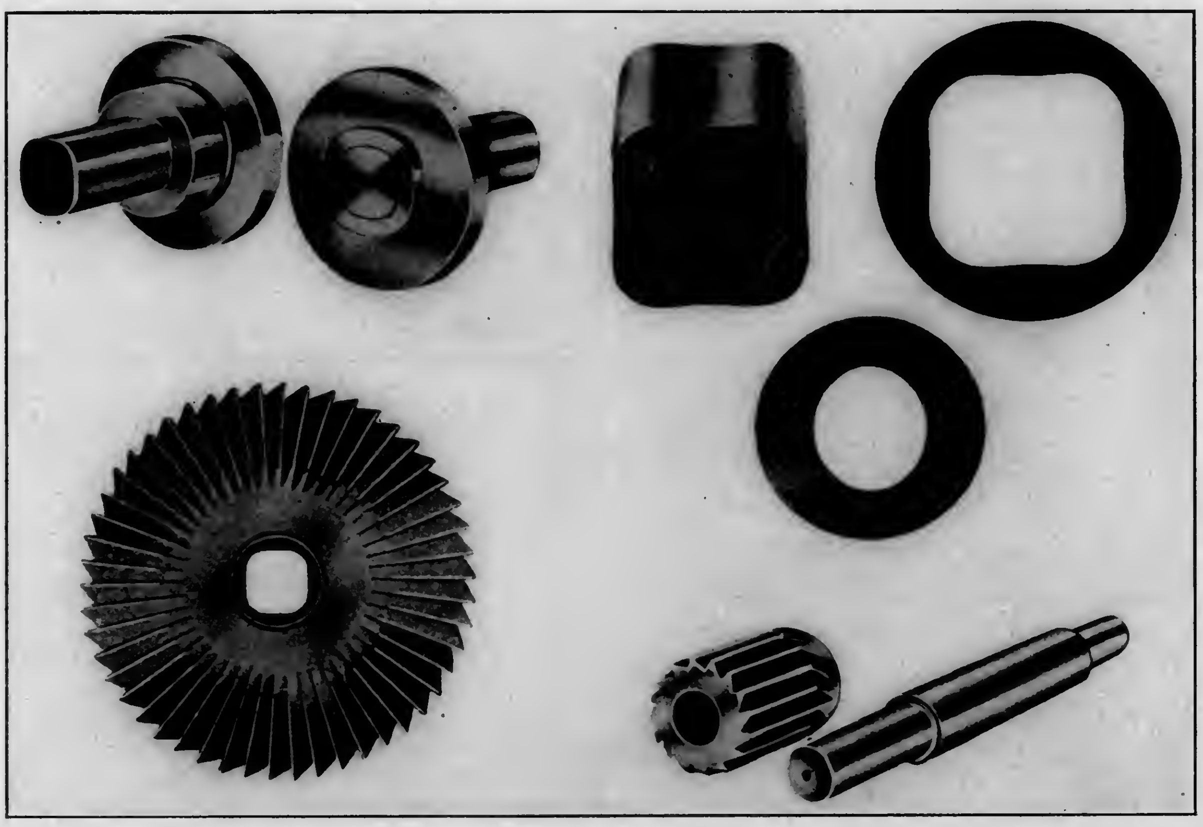
THE DERRER UNIVERSAL SHAPE ATTACHMENT APPLIED TO A LODGE & SHIPLEY LATHE.

THE OVAL DRIVE AND ITS USES.

The Derrer universal shape attachment, or oval drive, exhibited at the Atlantic City conventions by the Lancaster Machine & Knife Works, Lancaster, N. Y., will undoubtedly find a considerable field of usefulness and prove of great value in railroad shop tool rooms. The exhibit consisted of a Lodge & Shipley Machine Tool Company three step cone, double back geared, standard screw cutting engine lathe, on which was mounted a Derrer universal shape attachment. This is a simply constructed device, having sensitive and quick adjustment for turning and boring a wide range of hitherto unobtainable shapes, such as eccentrics, ovals, cams and squares, which may be made either straight or taper at a low labor cost.

The lengthened lathe spindle carries a gear that drives through an intermediate into a gear upon the splined shaft, shown at the rear of the lathe. Suitable gears are furnished to give this shaft ratios to the spindle of 1 to 1 for eccentrics, 2 to 1 for ovals, 3 to 1 for cams, 4 to 1 for squares, and increased ratios for greater polygons. The length of the shaft is such that the attachment will operate at any point between the centers of the lathe or on chuck work, a pair of universal joints insuring the alignment of the shaft to the bearings.

The eccentric discs are mounted upon a long lower slide that



UPPER LEFT HAND CORNER—SHAFT COUPLING, SPECIAL SHAPE; UPPER RIGHT HAND CORNER—SAMPLES OF WORK MADE WITH THE OVAL DRIVE; LOWER LEFT HAND—MILLING CUTTER ARRANGED FOR SPECIAL SHAPE ARBOR; LOWER RIGHT HAND—SHELL REAMER WITH OVAL TAPER ARBOR.

moves directly upon the bridge of the lathe carriage and extends out and over the taper attachment and is bolted to the shoe or sliding block on the taper dovetail; consequently taper ovals, eccentrics, squares, etc., may be bored and turned. The bearing blocks are cast integral with the slide. In these bearings is a sleeve carried upon the splined shaft and free to revolve with it. Two eccentrics, one within the other, and the bronze eccentric strap coupled directly to the compound rest slide, complete the drive. By easily made adjustment it is possible to obtain any throw from zero to the combined throw of both eccentrics. On the 16 in. lathe this maximum is ½ in. for ovals, squares and cams, but this can be increased to almost any throw by special eccentrics and by lengthening out the crotch of the cross slide. A graduated disc makes it a simple matter to obtain the desired throw quickly. Solid eccentrics (not adjustable) may be substituted for the above, when a large quantity of duplicate work is required.

As the tool is at all times tangent to the cut in boring and turning (either straight or taper), two ends of a taper hole

LANCASTER OVAL TAPER DRILL SOCKET.

would have similar ellipses, the large and small axis having a constant ratio to each other. In boring or turning shapes the lathe is run with the same precision as in turning or boring rounds. For taper round turning, disengage the gear driving the shaft on the end of the spindle. For straight round turning, disengage the gear and back off the dog of the taper attachment. Either of the above changes may be made in less than a minute's time. Ample oiling facilities are provided for all wearing surfaces of the attachment. In addition to the above described equipment, a depth gauge is fitted to the compound rest screw whereby all diameters can be easily and positively duplicated in boring or turning. A gauge is also furnished for locating the cutting edge of the tool for all cutting conditions.

APPLICATIONS.

An important application of this drive is its use in connection with milling cutters, shell reamers and all similar tools, at present held in place by methods that cause much loss through cracking in hardening in their manufacture. Tool steel has a tendency to crack at sharp corners and the elimination of keyways by using a specially shaped arbor would greatly reduce this trouble and at the same time furnish a stronger and more satisfactory method of holding the tool.

The use of the flat tang for holding twist drills has not proved satisfactory, and the manufacturers and users of such tools have been striving for years to perfect some scheme for holding drills for true driving at all times, and without injury to the shank of the drill. The Lancaster oval taper drill socket, shown in the illustration, is made possible by the oval drive. The company is placing a full line of these drill sockets and sleeves on the market, and is prepared to furnish twist drills of standard make with shanks turned to accurately fit the sockets. These sockets have given very satisfactory results. A standard taper of ⅜ in. to the foot has been adopted.

The use of the oval drive in the manufacture of shaft couplings insures a permanent, lasting union, that is practically indestructible. By using the square design with ends of the shafts tapered, a most secure and positive drive is procured without the use of keys, screws or other holding devices. The couplings can be separated quickly and be again put together without the necessity of refacing, as is customary in the present readjustment of flange couplings.

The drive may be used to advantage in many instances for the fastening of gears to shafts, instead of keying them; for turning the shafts for back gears and for many other similar purposes. The oval drive has been in practical and constant use at the plant of the Algoma Steel Company, Ltd., Sault Ste Marie, Ontario, for two years.

LOCOMOTIVE FEED WATER HEATER TESTS.

A feed water heater for locomotives which was designed by F. H. Trevithick, superintendent of motive power of the Egyptian State Railways, and applied by him to several locomotives on that system, was illustrated and described on page 436 of the November, 1907, issue of this journal. A series of tests which were recently made with this heater are reported in a pamphlet being issued by the North British Locomotive Company, Ltd., at the Franco-British Exhibition, from which the following results are taken.

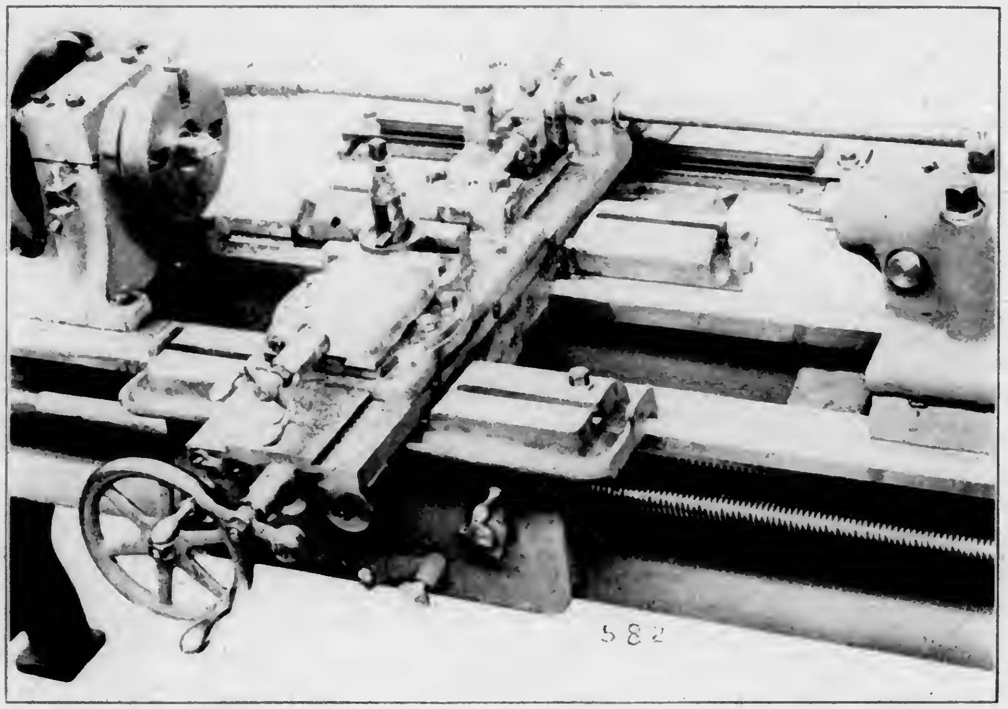
The first series of trials consisted of comparing the results in regular operation of a locomotive, both with and without the heaters. These tests covered 14 trips from Cairo to Alexandria, a total of 1,820 miles with heaters, and 18 trips, 2,340 miles without them. The average consumption of coal per mile with a train which averaged 219 tons was 27.32 lbs. without heaters and 22.12 lbs. with them, a difference of 19 per cent. The evaporation per lb. of coal was 9.77 lbs. of water without heaters and 12.31 lbs. with them, a difference of 26 per cent. A series of runs were then made for obtaining the average temperature of the feed water after passing through the heaters. This was found to average 260 degrees, including temperatures obtained while standing, and 252 degrees while running only.

A test of the evaporation efficiency of a locomotive fitted with heaters as against a similar engine without them gave a result of 26 per cent. in favor of the former.

The next series of tests were a comparison in regular service of a locomotive fitted with heaters with a duplicate engine not so fitted and operating in the same service. These tests covered a distance of 7,280 miles in passenger service in each case and showed an average fuel economy in favor of the heaters of 22.4 per cent. per train mile and 23 per cent. per ton mile.

All of these tests were carried out with the greatest care and fairness. The full account of the methods used and the detailed results are given in the pamphlet mentioned.

TIMBER PRODUCTION.—Optimistic people when urged to lend their influence for forest preservation and restoration sometimes say that cement and concrete are going to take the place of lumber and so reduce the drain on the forests. Perhaps the prediction may be realized, but the figures for lumber production in 1907 give no hint of such relief. Lumber production is growing instead of falling off. The total of 1907 was 3,000,000 M. ft. greater than in 1906, and exceeded 40 billion ft. B. M.—*Engineering News.*



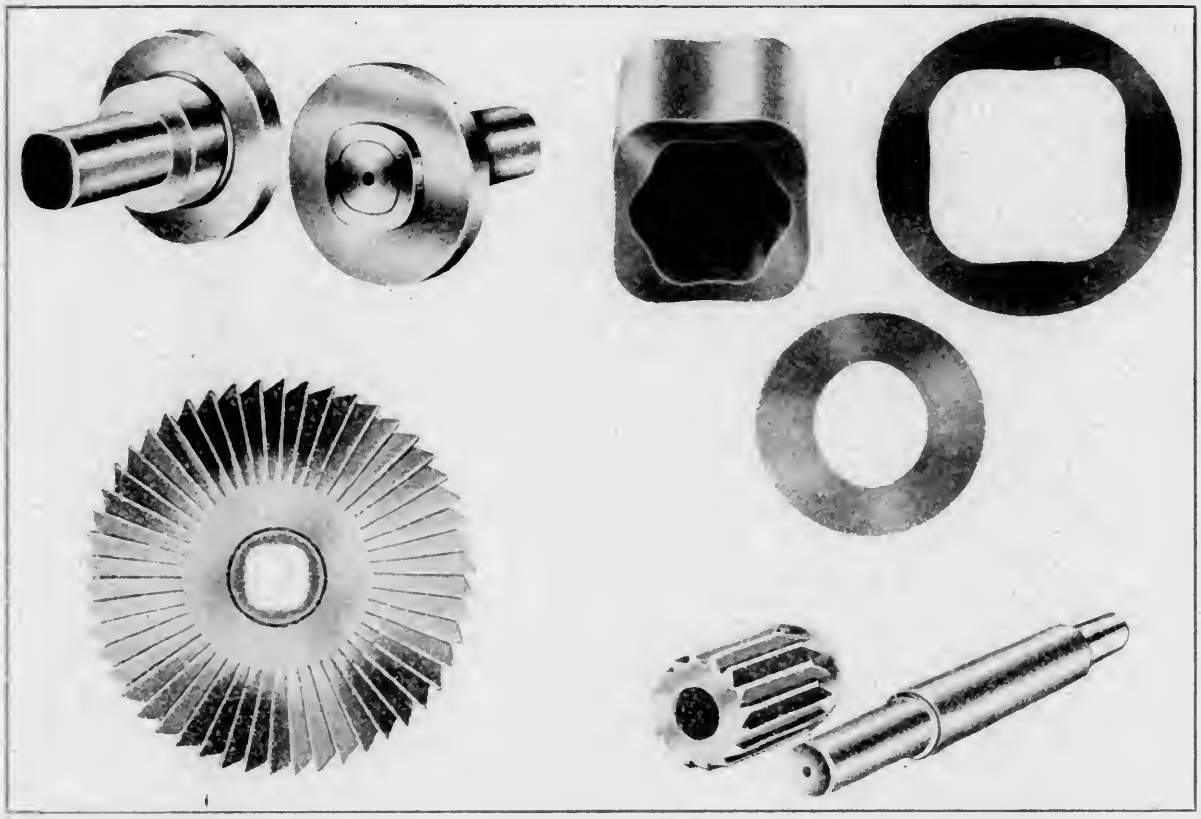
THE DERRER UNIVERSAL SHAPE ATTACHMENT APPLIED TO A LODGE & SHIPLEY LATHE.

THE OVAL DRIVE AND ITS USES.

The Derrer universal shape attachment, or oval drive, exhibited at the Atlantic City conventions by the Lancaster Machine & Knife Works, Lancaster, N. Y., will undoubtedly find a considerable field of usefulness and prove of great value in railroad shop tool rooms. The exhibit consisted of a Lodge & Shipley Machine Tool Company three step cone, double back geared, standard screw cutting engine lathe, on which was mounted a Derrer universal shape attachment. This is a simply constructed device, having sensitive and quick adjustment for turning and boring a wide range of hitherto unobtainable shapes, such as eccentrics, ovals, cams and squares, which may be made either straight or taper at a low labor cost.

The lengthened lathe spindle carries a gear that drives through an intermediate into a gear upon the splined shaft, shown at the rear of the lathe. Suitable gears are furnished to give this shaft ratios to the spindle of 1 to 1 for eccentrics, 2 to 1 for ovals, 3 to 1 for cams, 4 to 1 for squares, and increased ratios for greater polygons. The length of the shaft is such that the attachment will operate at any point between the centers of the lathe or on chuck work, a pair of universal joints insuring the alignment of the shaft to the bearings.

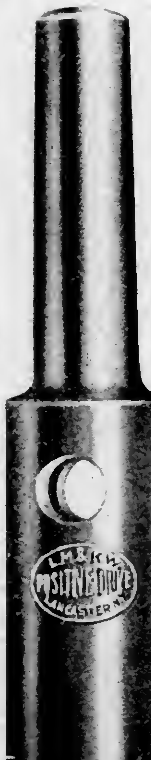
The eccentric discs are mounted upon a long lower slide that



UPPER LEFT HAND CORNER—SHAFT COUPLING, SPECIAL SHAPE; UPPER RIGHT HAND CORNER—SAMPLES OF WORK MADE WITH THE OVAL DRIVE; LOWER LEFT HAND—MILLING CUTTER ARRANGED FOR SPECIAL SHAPE ARBOR; LOWER RIGHT HAND—SHELL REAMER WITH OVAL TAPER ARBOR.

moves directly upon the bridge of the lathe carriage and extends out and over the taper attachment and is bolted to the shoe or sliding block on the taper dovetail; consequently taper ovals, eccentrics, squares, etc., may be bored and turned. The bearing blocks are cast integral with the slide. In these bearings is a sleeve carried upon the splined shaft and free to revolve with it. Two eccentrics, one within the other, and the bronze eccentric strap coupled directly to the compound rest slide, complete the drive. By easily made adjustment it is possible to obtain any throw from zero to the combined throw of both eccentrics. On the 16 in. lathe this maximum is ½ in. for ovals, squares and cams, but this can be increased to almost any throw by special eccentrics and by lengthening out the crotch of the cross slide. A graduated disc makes it a simple matter to obtain the desired throw quickly. Solid eccentrics (not adjustable) may be substituted for the above, when a large quantity of duplicate work is required.

As the tool is at all times tangent to the cut in boring and turning (either straight or taper), two ends of a taper hole



LANCASTER OVAL TAPER DRILL SOCKET.

would have similar ellipses, the large and small axis having a constant ratio to each other. In boring or turning shapes the lathe is run with the same precision as in turning or boring rounds. For taper round turning, disengage the gear driving the shaft on the end of the spindle. For straight round turning, disengage the gear and back off the dog of the taper attachment. Either of the above changes may be made in less than a minute's time. Ample oiling facilities are provided for all wearing surfaces of the attachment. In addition to the above described equipment, a depth gauge is fitted to the compound rest screw whereby all diameters can be easily and positively duplicated in boring or turning. A gauge is also furnished for locating the cutting edge of the tool for all cutting conditions.

APPLICATIONS.

An important application of this drive is its use in connection with milling cutters, shell reamers and all similar tools, at present held in place by methods that cause much loss through cracking in hardening in their manufacture. Tool steel has a tendency to crack at sharp corners and the elimination of keyways by using a specially shaped arbor would greatly reduce this trouble and at the same time furnish a stronger and more satisfactory method of holding the tool.

The use of the flat tang for holding twist drills has not proved satisfactory, and the manufacturers and users of such tools have been striving for years to perfect some scheme for holding drills for true driving at all times, and without injury to the shank of the drill. The Lancaster oval taper drill socket, shown in the illustration, is made possible by the oval drive. The company is placing a full line of these drill sockets and sleeves on the market, and is prepared to furnish twist drills of standard make with shanks turned to accurately fit the sockets. These sockets have given very satisfactory results. A standard taper of ⅝ in. to the foot has been adopted.

The use of the oval drive in the manufacture of shaft couplings insures a permanent, lasting union, that is practically indestructible. By using the square design with ends of the shafts tapered, a most secure and positive drive is procured without the use of keys, screws or other holding devices. The couplings can be separated quickly and be again put together without the necessity of refacing, as is customary in the present readjustment of flange couplings.

The drive may be used to advantage in many instances for the fastening of gears to shafts, instead of keying them; for turning the shafts for back gears and for many other similar purposes. The oval drive has been in practical and constant use at the plant of the Algoma Steel Company, Ltd., Sault Ste Marie, Ontario, for two years.

LOCOMOTIVE FEED WATER HEATER TESTS.

A feed water heater for locomotives which was designed by F. H. Trevithick, superintendent of motive power of the Egyptian State Railways, and applied by him to several locomotives on that system, was illustrated and described on page 436 of the November, 1907, issue of this journal. A series of tests which were recently made with this heater are reported in a pamphlet being issued by the North British Locomotive Company, Ltd., at the Franco-British Exhibition, from which the following results are taken.

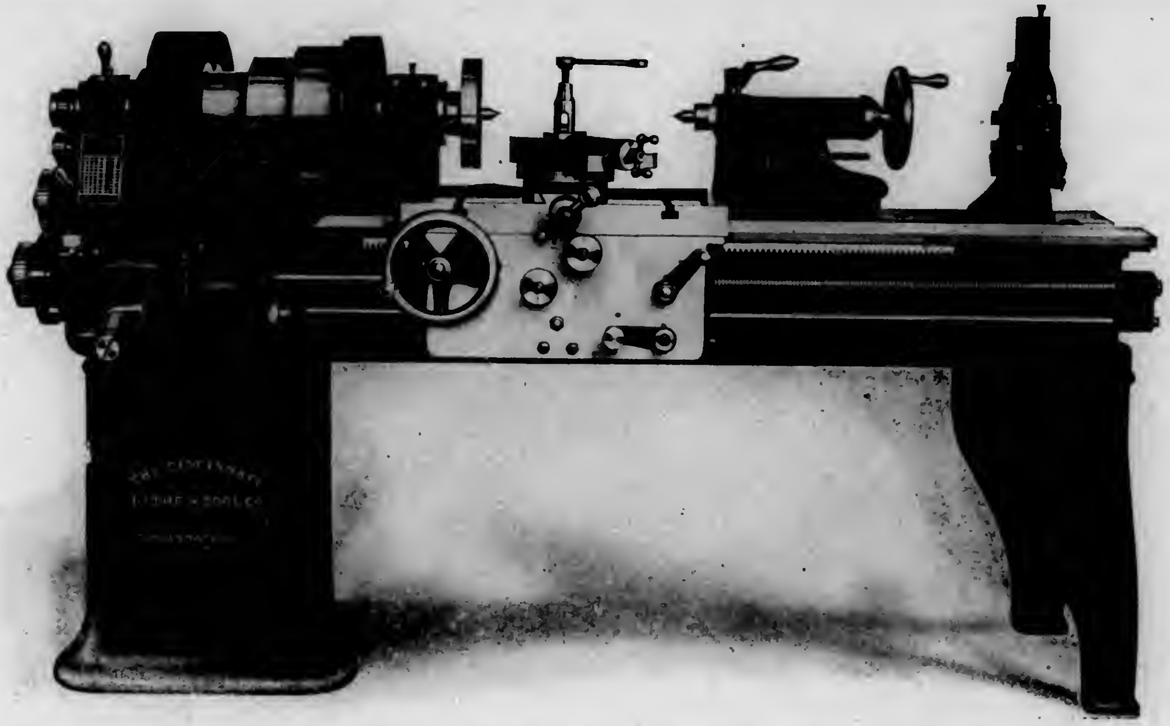
The first series of trials consisted of comparing the results in regular operation of a locomotive, both with and without the heaters. These tests covered 14 trips from Cairo to Alexandria, a total of 1,820 miles with heaters, and 18 trips, 2,340 miles without them. The average consumption of coal per mile with a train which averaged 219 tons was 27.32 lbs. without heaters and 22.12 lbs. with them, a difference of 19 per cent. The evaporation per lb. of coal was 9.77 lbs. of water without heaters and 12.31 lbs. with them, a difference of 26 per cent. A series of runs were then made for obtaining the average temperature of the feed water after passing through the heaters. This was found to average 200 degrees, including temperatures obtained while standing, and 252 degrees while running only.

A test of the evaporation efficiency of a locomotive fitted with heaters as against a similar engine without them gave a result of 26 per cent. in favor of the former.

The next series of tests were a comparison in regular service of a locomotive fitted with heaters with a duplicate engine not so fitted and operating in the same service. These tests covered a distance of 7,280 miles in passenger service in each case and showed an average fuel economy in favor of the heaters of 22.1 per cent. per train mile and 23 per cent. per ton mile.

All of these tests were carried out with the greatest care and fairness. The full account of the methods used and the detailed results are given in the pamphlet mentioned.

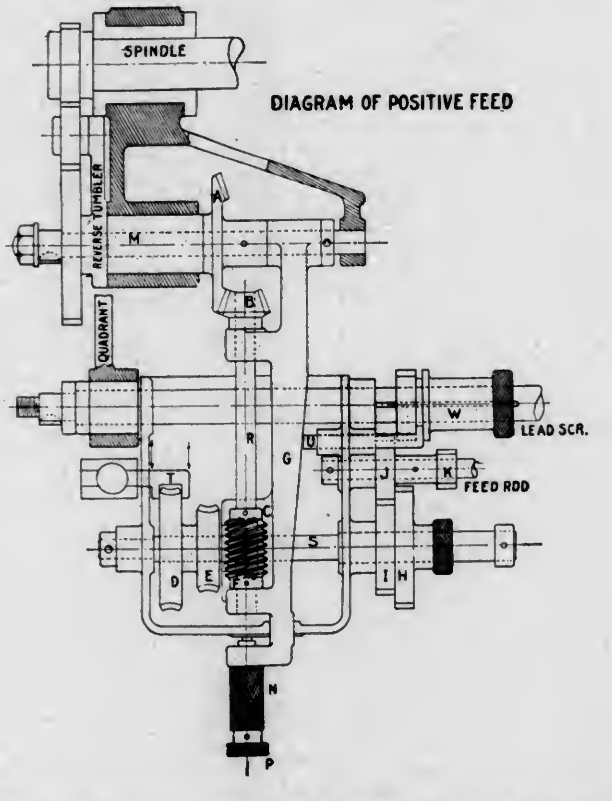
TIMBER PRODUCTION.—Optimistic people when urged to lend their influence for forest preservation and restoration sometimes say that cement and concrete are going to take the place of lumber and so reduce the drain on the forests. Perhaps the prediction may be realized, but the figures for lumber production in 1907 give no hint of such relief. Lumber production is growing instead of falling off. The total of 1907 was 3,000,000 M. ft. greater than in 1906, and exceeded 40 billion ft. B. M.—*Engineering News.*



SIXTEEN-INCH LATHE WITH NEW GEARED FEED DEVICE.

CINCINNATI SIXTEEN INCH LATHE WITH NEW GEARED FEED DEVICE.

Those who are familiar with the instantaneous change gear engine lathe with the W. T. Emmes patent feed device, made by The Cincinnati Lathe & Tool Company, Cincinnati, Ohio, will be interested in a recently designed lathe with a new type of positive geared feed which that company has placed on the



market. The former design was of special value for screw cutting, as it was possible to obtain any one of forty positive changes for that purpose by simply manipulating two knobs.

The details of the new geared feed device are shown on the drawing. The shaft M is connected to the spindle by a train of gears. The bevel gear A, which is keyed to M, drives pinion B on shaft R, to which the worm C is keyed. Shaft R is supported by the bracket, or arm G, which swings on the shaft M. G can therefore be moved up and down by means of the handle N, thus making it possible to have worm C mesh with either one of the three gears D, E or F. The worm gears are shifted by the fork T. Through the two pairs of gears I and J, and H and K, the three speeds at which it is possible to drive shaft S are doubled when transmitted to the feed rod, thus making six feeds available, which is all that are usually necessary on a 16-inch lathe for general manufacturing purposes. Twenty-two additional feed changes, ranging from 5 to 64 per inch, may be secured through the lead screw by sliding gear W into mesh with gear J on the feed rod. Safety stop U prevents the two feeds from becoming engaged at the same time. The 4 pitch lead screw cuts threads from 2 to 24 per inch, including 11½, and an unlimited number of other feeds may be obtained by ordering extra change gears for screw cutting. Arrangements are provided to oil the gears well.

The sixteen inch lathe illustrated has a swing over the bed of 16½ in., a swing over the carriage of 10¼ in., and may be equipped with either a three or a five step cone driving pulley. The back gear ratio with the five step cone is 10 to 1. Double back gears are provided with the three step cone, the back gear ratios being 3⅓ and 9½ to 1. The carriage has a bearing 22 in. long on the bed and the lathe with a 6 ft. bed weighs about 2,000 lbs.

A taper attachment may be added to the lathe at any time and permits turning tapers from 0 to 4 in. to the foot and 12 in. long at one setting. Where desired the lathe may also be furnished with a draw-in attachment, oil pan and a turret on the carriage.

Underground Railroads in Paris.—Paris has 32 miles of underground railroad in operation, and 25 additional miles are in process of construction. About 350,000 passengers are being carried per day. The system has a double track tunnel throughout, except where it crosses under the Seine, through two iron lined tubes, each 16.4 ft. inside diameter.

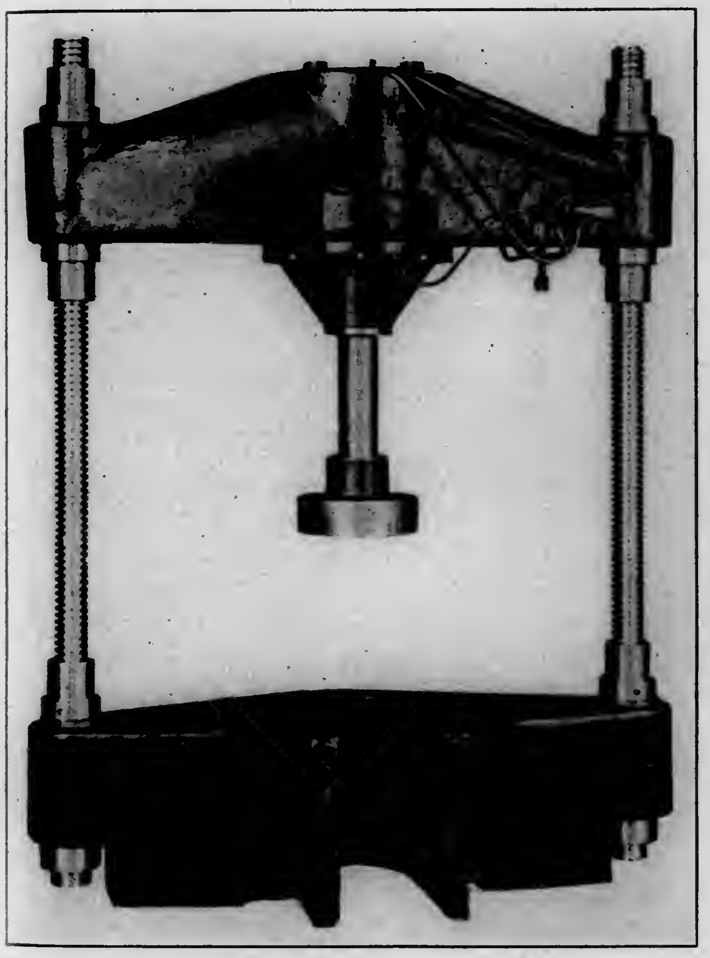
Master Car and Locomotive Painters' Association.—This association will hold its annual meeting at Atlantic City, September 8 to 11. A. P. Dane, B. & M. R. R., Reading, Mass., is the secretary.

PNEUMATIC PRESS.

A recently designed pneumatic press, suitable for railroad shop work, is shown in the illustration. The Springfield Machine Tool Company, Springfield, Ohio, designed and built one of these presses for their own use; it proved so successful that the company has decided to manufacture and place them on the market. When supplied with an air pressure of 80 lbs. per sq. in. the press is capable of exerting a pressure of 8,800 lbs. An auxiliary air pump, not shown in the illustration, may be thrown into action, which increases the capacity of the press to 27,000 lbs. The base of the machine is of heavy construction and large enough to take a piece of work 40 in. wide.

The opening in the base casting extends back beyond the center of the machine and permits a portion of the work, such as a shaft or pin, to extend a considerable distance below the top of the base.

The upper frame casting contains in its center the air cylinder, 12 inches in diameter, the piston having an 8-inch stroke;



SPRINGFIELD PNEUMATIC PRESS.

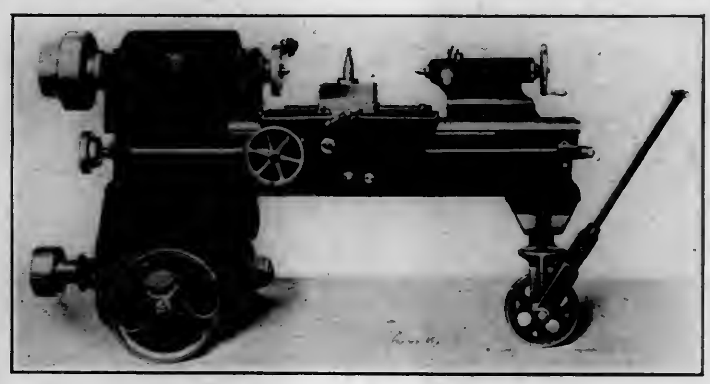
if required the stroke can be made longer. The piston is fitted with three rings, which prevents air leakage. The lower end of the piston rod carries a heavy circular shoe, the central portion of which is filled with babbitt, so that the work will not be bruised when the pressure is applied. The two uprights are threaded to permit adjusting the upper casting to the height required by the work. By the use of the adjusting screws the press can be made to accommodate a great variety of work.

The control of the air for the cylinder is through a valve at the right-hand side of the upper frame casting. The valve is very simple in its operation. As it is moved from the left-hand position the piston is raised, while a further movement will shut off all the air; then by moving the handle still further in the same direction, the piston is lowered, which permits the full air pressure to be applied to the work. If the pressure thus obtained does not prove to be sufficient, a further movement of the controlling handle in the same direction throws into operation a small, quick-acting air pump, which is placed on the top of the upper frame, but is not shown in the illustration. This pump is capable of raising the pressure to 250 pounds, when the main line is supplied with air having 80 pounds pressure to the square inch. The valve allows a very sensitive adjustment of the piston in either direction, and is so arranged that the piston cannot move too rapidly.

16-INCH PORTABLE LATHE.

The 16-inch portable lathe, illustrated herewith, was designed by the Lodge & Shipley Machine Tool Company, Cincinnati, Ohio, for use in fitting frame bolts, turning studs, etc., in locomotive repair shops. The machine can be wheeled alongside the locomotive, upon which the work is to be done, and a considerable saving in time and strength can be effected over the practice of carrying the parts to be fitted to the lathe department. An 18-inch lathe used for this purpose at the Collinwood shops of the Lake Shore & Michigan Southern was described on page 91 of the March, 1907, issue of this journal and a 16½-inch portable lathe, used at the Angus shops of the Canadian Pacific Railway was described on page 35 of the January, 1908, issue.

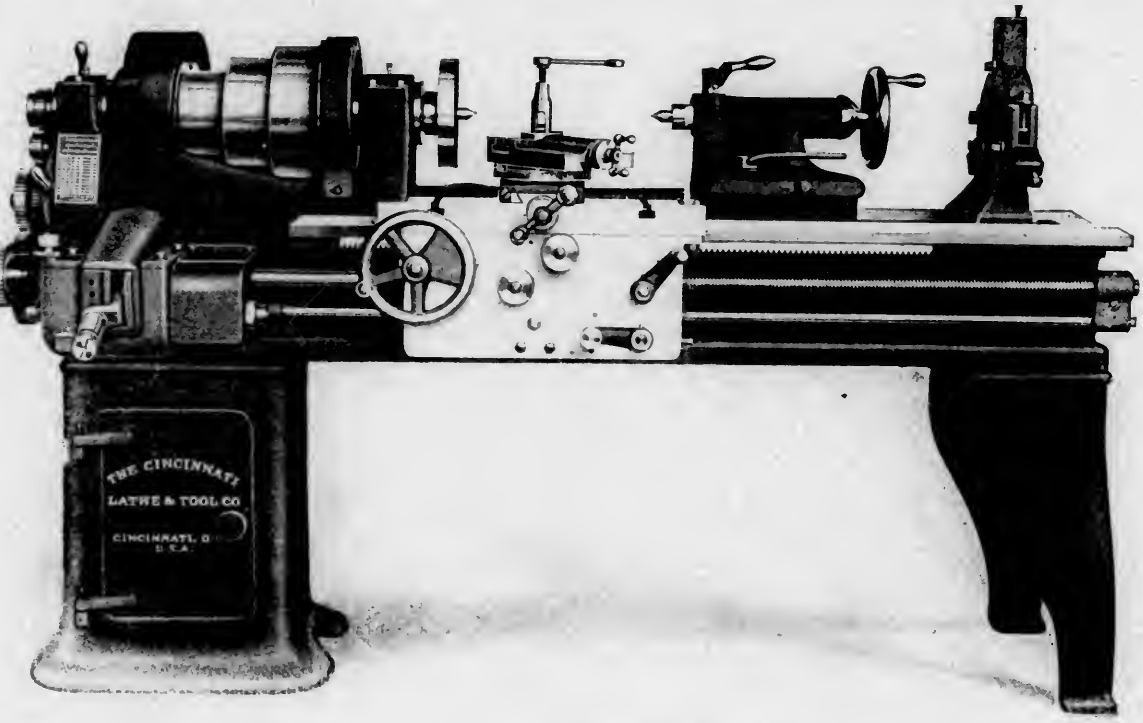
The lathe bed is mounted on three wheels and may be pulled about by one man on a fairly level floor. The motor is of a 2½ h.p., fully enclosed, constant speed type and is suspended underneath the headstock and belted to a two-step cone pulley, mounted upon the back gear shaft. The class of work to be handled does not require a wide range of spindle speed and the



LODGE & SHIPLEY PORTABLE LATHE.

two changes, which are provided, are thought to be ample. The lathe is supplied with a belt feed of two changes, a power longitudinal feed and a plain rest. If desired it can be supplied with a taper attachment; legs can also be furnished in place of the wheels.

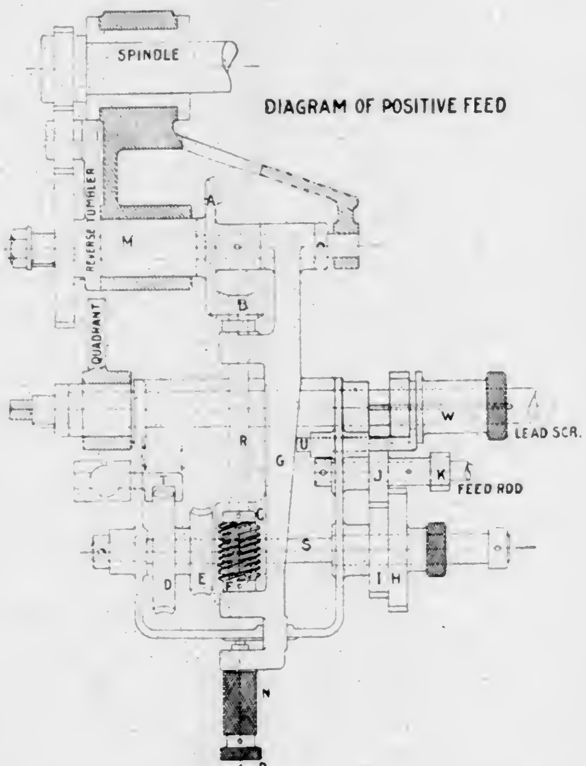
SIXTY-TWO STORY BUILDING.—Plans have been filed with the superintendent of buildings, of New York City, for a 62-story structure for the Equitable Life Assurance Society, to stand on the block bounded by Broadway, Nassau, Pine and Cedar streets. Including a tower, the building will rise to a height of 909 feet above the curb line, exclusive of a flagstaff, which will measure to the tip 150 feet more. The estimated cost is about $10,000,000. The design is by D. H. Burnham & Co., and shows that the main building will be of thirty-four stories or 489 feet, with a frontage of 167 feet on Broadway, 152 feet on Nassau street, 304 feet on Pine street and 312 feet on Cedar street. Above this building will rise a square tower of 28 stories capped with a cupola, the tower and cupola together to be 520 feet high. The main building is to be equipped with a group of thirty-eight passenger elevators built in two rows in a corridor finished in ornamental bronze. Eight of these will run to the top of the tower extension. No definite action has been taken as to just when the building will be erected.



SIXTEEN INCH LATHE WITH NEW GEARED FEED DEVICE.

CINCINNATI SIXTEEN INCH LATHE WITH NEW GEARED FEED DEVICE.

Those who are familiar with the instantaneous change gear engine lathe with the W. T. Emmes patent feed device, made by the Cincinnati Lathe & Tool Company, Cincinnati, Ohio, will be interested in a recently designed lathe with a new type of positive geared feed which that company has placed on the market. The former design was of special value for screw cutting, as it was possible to obtain any one of forty positive changes for that purpose by simply manipulating two knobs.



The details of the new geared feed device are shown on the drawing. The shaft M is connected to the spindle by a train of gears. The bevel gear A, which is keyed to M, drives pinion B on shaft R, to which the worm C is keyed. Shaft R is supported by the bracket, or arm G, which swings on the shaft M. G can therefore be moved up and down by means of the handle N, thus making it possible to have worm C mesh with either one of the three gears D, E or F. The worm gears are shifted by the fork T. Through the two pairs of gears I and J, and H and K, the three speeds at which it is possible to drive shaft S are doubled when transmitted to the feed rod, thus making six feeds available, which is all that are usually necessary on a 16-inch lathe for general manufacturing purposes. Twenty-two additional feed changes, ranging from 5 to 64 per inch, may be secured through the lead screw by sliding gear W into mesh with gear J on the feed rod. Safety stop U prevents the two feeds from becoming engaged at the same time. The 4 pitch lead screw cuts threads from 2 to 24 per inch, including 11½, and an unlimited number of other feeds may be obtained by ordering extra change gears for screw cutting. Arrangements are provided to oil the gears well.

The sixteen inch lathe illustrated has a swing over the bed of 16½ in., a swing over the carriage of 10¼ in., and may be equipped with either a three or a five step cone driving pulley. The back gear ratio with the five step cone is 10 to 1. Double back gears are provided with the three step cone, the back gear ratios being 3⅓ and 9½ to 1. The carriage has a bearing 22 in. long on the bed and the lathe with a 6 ft. bed weighs about 2,000 lbs.

A taper attachment may be added to the lathe at any time and permits turning tapers from 0 to 4 in. to the foot and 12 in. long at one setting. Where desired the lathe may also be furnished with a draw-in attachment, oil pan and a turret on the carriage.

Underground Railroads in Paris.—Paris has 32 miles of underground railroad in operation, and 25 additional miles are in process of construction. About 350,000 passengers are being carried per day. The system has a double track tunnel throughout, except where it crosses under the Seine, through two iron lined tubes, each 16.4 ft. inside diameter.

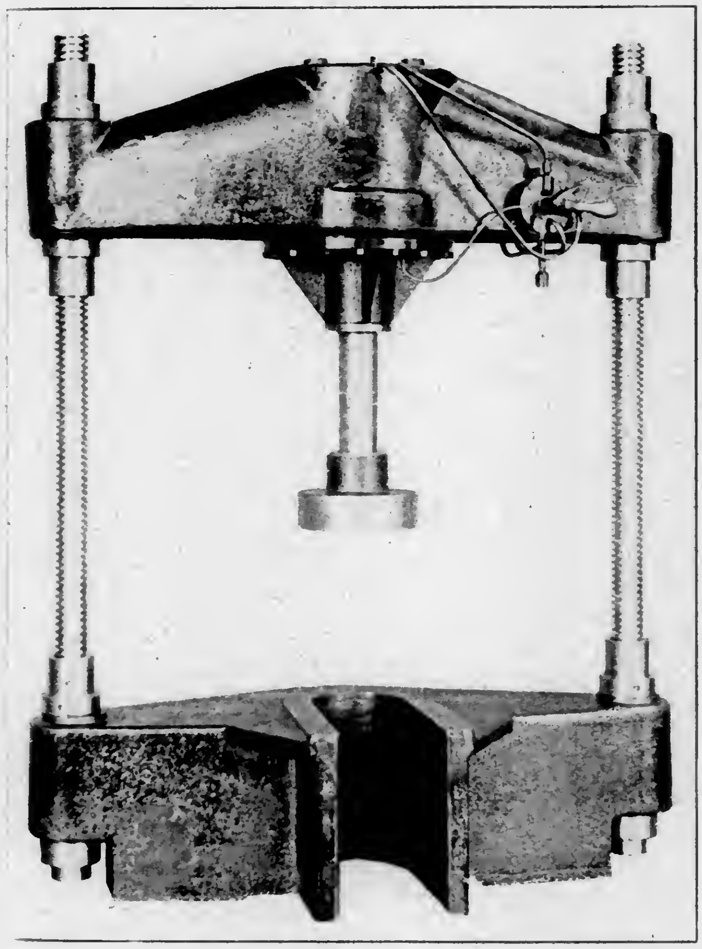
Master Car and Locomotive Painters' Association.—This association will hold its annual meeting at Atlantic City, September 8 to 11. A. P. Dane, B. & M. R. R., Reading, Mass., is the secretary.

PNEUMATIC PRESS.

A recently designed pneumatic press, suitable for railroad shop work, is shown in the illustration. The Springfield Machine Tool Company, Springfield, Ohio, designed and built one of these presses for their own use; it proved so successful that the company has decided to manufacture and place them on the market. When supplied with an air pressure of 80 lbs. per sq. in. the press is capable of exerting a pressure of 8,800 lbs. An auxiliary air pump, not shown in the illustration, may be thrown into action, which increases the capacity of the press to 27,000 lbs. The base of the machine is of heavy construction and large enough to take a piece of work 40 in. wide.

The opening in the base casting extends back beyond the center of the machine and permits a portion of the work, such as a shaft or pin, to extend a considerable distance below the top of the base.

The upper frame casting contains in its center the air cylinder, 12 inches in diameter, the piston having an 8-inch stroke;



SPRINGFIELD PNEUMATIC PRESS.

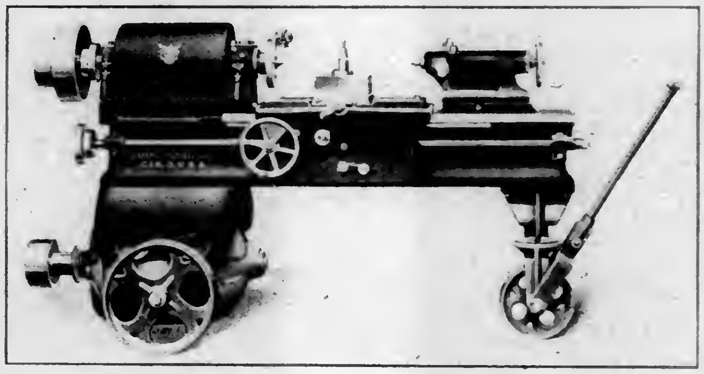
if required the stroke can be made longer. The piston is fitted with three rings, which prevents air leakage. The lower end of the piston rod carries a heavy circular shoe, the central portion of which is filled with babbitt, so that the work will not be bruised when the pressure is applied. The two uprights are threaded to permit adjusting the upper casting to the height required by the work. By the use of the adjusting screws the press can be made to accommodate a great variety of work.

The control of the air for the cylinder is through a valve at the right-hand side of the upper frame casting. The valve is very simple in its operation. As it is moved from the left-hand position the piston is raised, while a further movement will shut off all the air; then by moving the handle still further in the same direction, the piston is lowered, which permits the full air pressure to be applied to the work. If the pressure thus obtained does not prove to be sufficient, a further movement of the controlling handle in the same direction throws into operation a small, quick-acting air pump, which is placed on the top of the upper frame, but is not shown in the illustration. This pump is capable of raising the pressure to 250 pounds, when the main line is supplied with air having 80 pounds pressure to the square inch. The valve allows a very sensitive adjustment of the piston in either direction, and is so arranged that the piston cannot move too rapidly.

16-INCH PORTABLE LATHE.

The 16-inch portable lathe, illustrated herewith, was designed by the Lodge & Shipley Machine Tool Company, Cincinnati, Ohio, for use in fitting frame bolts, turning studs, etc., in locomotive repair shops. The machine can be wheeled alongside the locomotive, upon which the work is to be done, and a considerable saving in time and strength can be effected over the practice of carrying the parts to be fitted to the lathe department. An 18-inch lathe used for this purpose at the Collinwood shops of the Lake Shore & Michigan Southern was described on page 91 of the March, 1907, issue of this journal and a 16½-inch portable lathe, used at the Angus shops of the Canadian Pacific Railway was described on page 35 of the January, 1908, issue.

The lathe bed is mounted on three wheels and may be pulled about by one man on a fairly level floor. The motor is of a 2½ h.p., fully enclosed, constant speed type and is suspended underneath the headstock and belted to a two-step cone pulley, mounted upon the back gear shaft. The class of work to be handled does not require a wide range of spindle speed and the



LODGE & SHIPLEY PORTABLE LATHE.

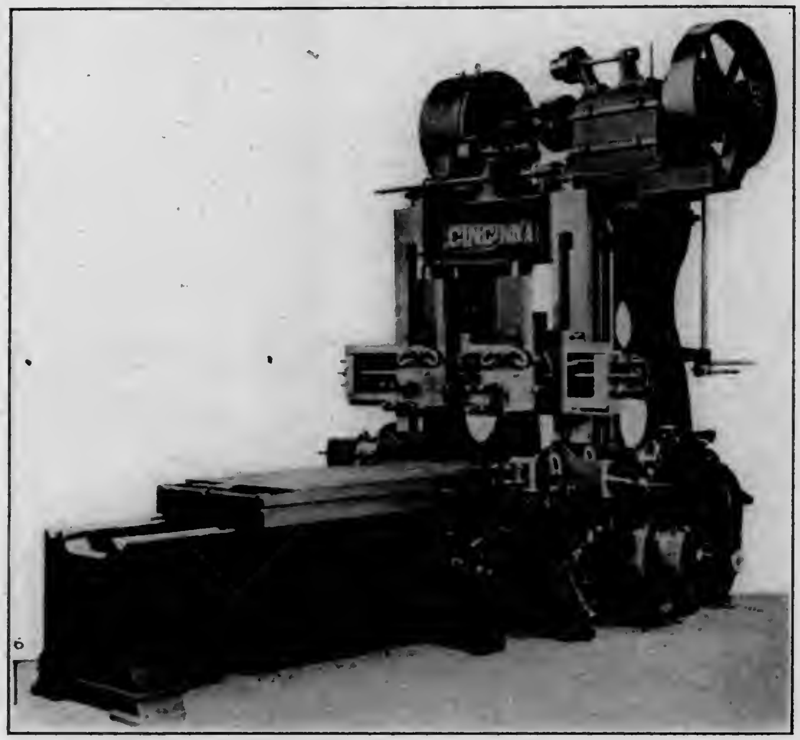
two changes, which are provided, are thought to be ample. The lathe is supplied with a belt feed of two changes, a power longitudinal feed and a plain rest. If desired it can be supplied with a taper attachment; legs can also be furnished in place of the wheels.

SIXTY-TWO STORY BUILDING.—Plans have been filed with the superintendent of buildings, of New York City, for a 62-story structure for the Equitable Life Assurance Society, to stand on the block bounded by Broadway, Nassau, Pine and Cedar streets. Including a tower, the building will rise to a height of 909 feet above the curb line, exclusive of a flagstaff, which will measure to the tip 150 feet more. The estimated cost is about $10,000,000. The design is by D. H. Burnham & Co., and shows that the main building will be of thirty-four stories or 489 feet, with a frontage of 167 feet on Broadway, 152 feet on Nassau street, 304 feet on Pine street and 312 feet on Cedar street. Above this building will rise a square tower of 28 stories capped with a cupola, the tower and cupola together to be 520 feet high. The main building is to be equipped with a group of thirty-eight passenger elevators built in two rows in a corridor finished in ornamental bronze. Eight of these will run to the top of the tower extension. No definite action has been taken as to just when the building will be erected.

37-INCH HEAVY VARIABLE SPEED FORGE PLANER.

The heavy forge planer, illustrated herewith, was exhibited at the Atlantic City conventions by The Cincinnati Planer Company, Cincinnati, Ohio. It was driven by a 15 h.p. constant speed motor which transmitted power to the speed box through a rawhide pinion and a cast iron gear. The speed box furnished four changes of cutting speed, 20, 28, 35, and 45 ft. per minute, with a constant return speed of 80 ft. per minute. The speeds are changed by the vertical shaft and handles, shown at the right. The speed box is enclosed and all the gears run in oil.

The bed is made of extra length, so that there is very little overhang of the table when planing at full stroke. The V's are fitted with automatic roller oiling devices. The table is carefully designed for unusual strength and stiffness and is arranged with a dustproof feature which prevents the chips from falling into the V's. A complete shifting mechanism is furnished on both sides. A considerable improvement has been made in the tumbler, the surfaces of the tumbler and dog which come in contact, being designed so that these parts roll, instead of slide on each other. Wear on these parts is thus practically eliminated.



CINCINNATI 37-INCH HEAVY FORGE PLANER.

The housings, of heavy box construction, are carried down to the bottom of the bed and are fastened to it by heavy bolts and dowel pins; in addition they are secured to it by a long tongue and groove. They are tied at the top by the heavy box-shaped arch. The cross rail has large bearings on the housings and is stiffened by an arch-shaped brace at the rear. It is of sufficient length to allow either one of the two heads to traverse the full width of the table. The heads are of a new shape, the end of the tool block and slide being made round to clear projecting corners on angular work. They are provided with taper gibs, and the slides are hung on ball bearings. The heads are made right and left, and are provided with automatic feed in all directions. Side heads are fitted on both housings, with independent power and hand vertical feed, and can be run below the top of table when not in use. The handles, which control the feeds, travel up and down with the heads and are therefore always convenient to the operator. The side head tool block, to which the planing tool is fastened, is fitted with a little handle for throwing out the spring which holds it down. The tool blocks on the rail heads fall back in place by gravity, but on the side heads it is necessary to use a spring to force them back in place. When they are moved out slightly on the return stroke, owing to the fact that it is frequently necessary to look at the tool or rub it up with an oil stone, it has been heretofore a little troublesome to pull them out on account of this spring; with this little handle it is only necessary to push the handle down and the tool block may be pulled out its full limit. Provision is made so the side heads may be attached to machines not equipped with them when purchased, at any future time. A patent elevating device is located at the center of the arch and provides a third bearing for the elevating shaft, distributing the pull equally. This device is driven by a belt connected to the pulley, mounted on the brackets above the speed box, which is in turn driven from the speed box shaft. Ordinarily the elevating device is driven direct from the speed box shaft, but the construction of this particular machine would not admit of doing this.

A combination friction insures positive feed when the heaviest cuts are being taken. The shifter is provided with a safety locking device to prevent the table from starting except at the will of the operator.

THE REAL PURPOSE OF THE STORES DEPARTMENT.—First: To furnish material when and where it is wanted.

Second: To properly, promptly and economically care, handle and account for it.

Third: Proper inspection and check to see that the railroad gets what it buys.

Fourth: To maintain standards by seeing that the proper name and description is maintained.

Fifth: Classify and place requisitions far enough in advance and in such quantities as to enable the purchasing agent to make judicious purchases.

Sixth: Classify and order material in such quantities as to get the benefit of carload rates of freight.

Seventh: Finance resources by keeping material in as few places as possible, and in such shape that it is ready to move when required.

Eighth: Prompt and certain deliveries only in such quantities as are actually needed.

Ninth: Keep only a minimum amount of material on hand.—*H. C. Pearce before the Railway Storekeepers' Association.*

LARGE FRENCH METAL WORKING PLANT.—The Creusot works of Schneider & Company in France occupy an area of about 3,300 acres and extend uninterruptedly for a distance of three miles. The different departments are connected by a system of railways 200 miles in length, with a rolling stock of 55 locomotives and 1,600 cars. The number of employees of all classes varies from 15,500 to 16,000. —*American Machinist.*

EXHAUSTION OF OUR COAL SUPPLY.—The exhaustion of our coal supply is not in the indefinite future. The startling feature of our coal production is not so much the magnitude of the annual output as its rate of growth. For the decade ending in 1905 the total product was 2,832,402,746 tons, which is almost exactly one-half the total product previously mined in this country. For the year 1906 the output was 414,000,000 tons, an increase of 46 per cent. on the average annual yield of the ten years preceding. In 1907 our production reached 470,000,000 tons. Fifty years ago the annual per capita production was little more than one-quarter of a ton. It is now about five tons. Estimates of coal deposits still remaining must necessarily be somewhat vague. The best authorities do not rate them at much over 2,000,000,000,000 tons. If coal production continues to increase as it has in the last ninety years, the available supply will be greatly reduced by the close of the century. Before that time arrives, however, resort to lower grades and sinking of mines to greater depths will become necessary, making the product inferior in quality and higher in price.—*James J. Hill before the Governors' Conference.*

WHAT THE RAILROAD CLUBS WILL DO IN SEPTEMBER.

Canadian Railway Club (Montreal).—R. E. Johnson, of the Canadian Fairbanks Company, Montreal, will present a paper on "Gas Producer Plants," September 1st, at the Windsor Hotel. Secretary, Jas. Powell, P. O. Box 7, St. Lambert, near Montreal.

Central Railway Club (Buffalo, N. Y.).—W. H. Evans, master mechanic of the International Railway Company, will read a paper on "Electric Traction vs. Steam Railroad Operation," Friday, September 11th. This is also the date of the fall outing of the club. A boat trip will be taken down the Niagara River, leaving at 10 A. M., and dinner will be served on Grand Island at 2:30 P. M. The return boat will reach the city at 7 P. M. The regular meeting of the club will be held on the boat en route. Secretary, Harry D. Vought, 62 Liberty street, New York City.

**Iowa Railway Club (Des Moines, Ia.)*—Meets September 11. Secretary, W. B. Harrison, Union Station, Des Moines, Ia.

New England Railroad Club (Boston).—Next regular meeting Ocotber 13th. Secretary, George H. Frazier, 10 Oliver street, Boston, Mass.

New York Railroad Club (New York City).—Raffe Emerson, assistant engineer of methods, Atchison, Topeka & Santa Fe Railway, will present a paper on "Handling Locomotive Supplies; Value of Proper Handling of Supplies; Supply Costs and Accounting; Design of Items of Engine Equipments; Methods of Handling Supplies and Equipments; Results," Friday, September 18th, at the Engineering Societies Building, 29 W. 39th street. Secretary, Harry D. Vought, 62 Liberty street, New York City.

**Northern Railway Club (Duluth, Minn.)*.—Meets September 25. Secretary, C. L. Kennedy, 401 West Superior street, Duluth, Minn.

North-West Railway Club.—This club, of Minneapolis and St. Paul, has discontinued its meetings for the present season.

**Railway Club of Pittsburgh (Pittsburgh)*.—Meets September 25. Secretary, J. D. Conway, P. & L. E. R. R., Pittsburgh, Pa.

**Richmond Railroad Club (Richmond, Va.)*.—Meets September 10. Secretary, F. O. Robinson, 8th and Main streets, Richmond, Va.

**Rocky Mountain Railway Club (Denver, Colo.)*.—Meets September 8th. Secretary, M. M. Currier, Box 229, Colorado City, Colo.

St. Louis Railway Club.—Prof. L. E. Young, director of the School of Mines and Metallurgy, Rolla, Mo., will address the meeting, Friday, September 11th. The exact subject has not yet been announced. Secretary, B. W. Frauenthal, Union Station, St. Louis, Mo.

Western Railway Club (Chicago).—Arthur Hale, chairman of the car service committee of the American Railway Association, will address the club on Tuesday evening, September 15th. Secretary, J. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

*Subject for discussion apparently not yet determined as no reply was received from the secretary up to the time of going to press. It is assumed that there will be no change in the time of holding the regular meeting.

UNIQUE ADAPTATION OF SHELBY TUBING.

At a banquet, recently given to the officials of the National Tube Company at Pittsburg, the dishes used were formed (not cast) from Shelby seamless steel tubing. As shown in the illustration, the material was hammered flat for the knife blade and spoon handles, was curved in or out for the bowls of the spoons

and for the plate and saucer, was left in its original shape for the napkin ring, was expanded at one end into several times its original diameter for the goblet, and was formed into a bell. It is said that over three hundred uses have been found for this tubing, and new uses are constantly being added.

PERSONALS

R. E. Fulmer has been appointed master mechanic of the Tremont & Gulf Ry., with office at Eros, La.

The office of the superintendent of motive power of the Mexican National R. R. has been transferred from Laredo, Tex., to San Luis Potosi.

W. C. Hayes, superintendent of the Erie at Susquehanna, has been appointed superintendent of locomotive operation, with headquarters in New York.

H. E. Lind has been appointed storekeeper for the Erie R. R. at Susquehanna, Pa., vice T. H. Keffer, resigned. H. J. Ackworth succeeds Mr. Lind as storekeeper at Kent, O.

R. B. Smith has been appointed foreman of motive power and equipment of the Cincinnati, Lebanon & Northern Ry., at Rendleton, O., succeeding John Stutter, resigned.

William Henry, assistant master mechanic of the St. Louis & San Francisco R. R., at Memphis, Tenn., has been appointed master mechanic with headquarters at Sapulpa, Okla.

William Baird, general car inspector of the Chicago, Burlington & Quincy Ry., has been appointed shop superintendent at the Plattsmouth, Neb., shops, succeeding H. J. Helps, resigned.

W. Hamilton, acting locomotive foreman of the Grand Trunk Ry., at Palmerston, Ont., has been appointed locomotive foreman at Stratford, Ont., succeeding J. A. Mitchell, resigned.

J. A. Mitchell, locomotive foreman of the Grand Trunk at Stratford, Ont., has been appointed locomotive foreman of the Grand Trunk Pacific, with office at Rivers, Man.

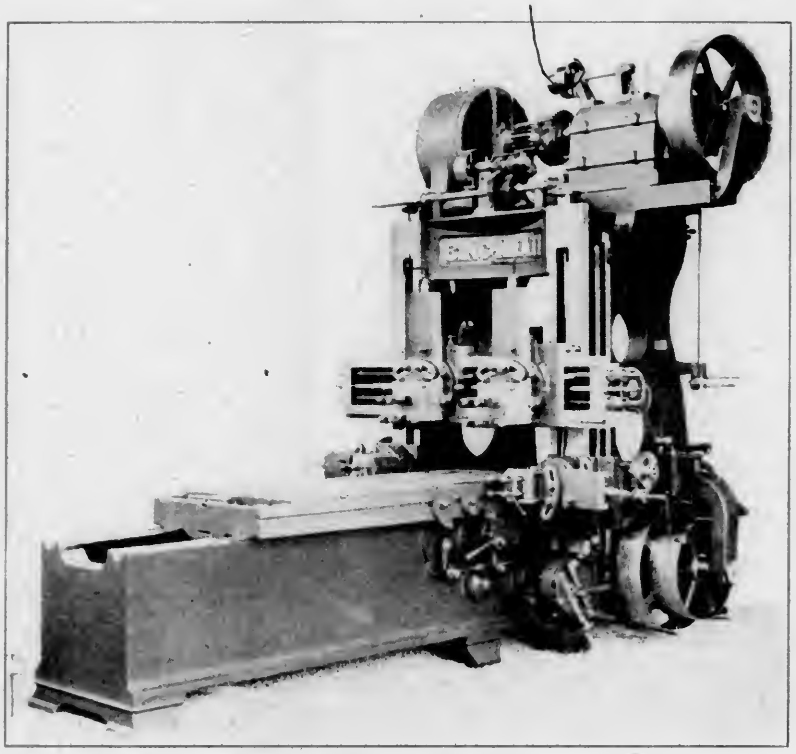
C. E. Gossett, master mechanic of the Chicago, Rock Island & Pacific at Armourdale, Kan., has been appointed master mechanic of the Iowa Central, succeeding T. M. Feeley, resigned.

G. W. Taylor has resigned as division master mechanic of the Atchison, Topeka & Santa Fe Ry., at Newton, Kan., to become superintendent of motive power of the San Antonio & Aransas Pass Ry., with headquarters at San Antonio, Tex., succeeding G. W. Butcher, resigned.

37-INCH HEAVY VARIABLE SPEED FORGE PLANER.

The heavy forge planer, illustrated herewith, was exhibited at the Atlantic City conventions by The Cincinnati Planer Company, Cincinnati, Ohio. It was driven by a 15 h.p. constant speed motor which transmitted power to the speed box through a raw hide pinion and a cast iron gear. The speed box furnished four changes of cutting speed, 20, 28, 35, and 45 ft. per minute, with a constant return speed of 80 ft. per minute. The speeds are changed by the vertical shaft and handles, shown at the right. The speed box is enclosed and all the gears run in oil.

The bed is made of extra length, so that there is very little overhang of the table when planing at full stroke. The V's are fitted with automatic roller oiling devices. The table is carefully designed for unusual strength and stiffness and is arranged with a dustproof feature which prevents the chips from falling into the V's. A complete shifting mechanism is furnished on both sides. A considerable improvement has been made in the tumbler, the surfaces of the tumbler and dog which come in contact, being designed so that these parts roll, instead of slide on each other. Wear on these parts is thus practically eliminated.



CINCINNATI 37-INCH HEAVY FORGE PLANER.

The housings, of heavy box construction, are carried down to the bottom of the bed and are fastened to it by heavy bolts and dowel pins; in addition they are secured to it by a long tongue and groove. They are tied at the top by the heavy box-shaped arch. The cross rail has large bearings on the housings and is stiffened by an arch shaped brace at the rear. It is of sufficient length to allow either one of the two heads to traverse the full width of the table. The heads are of a new shape, the end of the tool block and slide being made round to clear projecting corners on angular work. They are provided with taper gibs, and the slides are hung on ball bearings. The heads are made right and left, and are provided with automatic feed in all directions. Side heads are fitted on both housings, with independent power and hand vertical feed, and can be run below the top of table when not in use. The handles, which control the feeds, travel up and down with the heads and are therefore always convenient to the operator. The side head tool block, to which the planing tool is fastened, is fitted with a little handle for throwing out the spring which holds it down. The tool blocks on the rail heads fall back in place by gravity, but on the side heads it is necessary to use a spring to force them back in place. When they are moved out slightly on the return stroke, owing to the fact that it is frequently necessary to look at the tool rub it up with an oil stone, it has been heretofore a little trou[ble]some to pull them out on account of this spring; with this li[ttle] handle it is only necessary to push the handle down and the block may be pulled out its full limit. Provision is made so side heads may be attached to machines not equipped with th[em] when purchased, at any future time. A patent elevating dev[ice] is located at the center of the arch and provides a third bear[ing] for the elevating shaft, distributing the pull equally. This de[vice] is driven by a belt connected to the pulley, mounted on brackets above the speed box, which is in turn driven from speed box shaft. Ordinarily the elevating device is driven dir[ectly] from the speed box shaft, but the construction of this particu[lar] machine would not admit of doing this.

A combination friction insures positive feed when the heavy cuts are being taken. The shifter is provided with a safety locking device to prevent the table from starting except at the will of the operator.

THE REAL PURPOSE OF THE STORES DEPARTMENT.
First: To furnish material when and where it is wanted.

Second: To properly, promptly and economically care, handle and account for it.

Third: Proper inspection and check to see that the railroad gets what it buys.

Fourth: To maintain standards by seeing that the proper name and description is maintained.

Fifth: Classify and place requisitions far enough in advance and in such quantities as to enable the purchasing agent to make judicious purchases.

Sixth: Classify and order material in such quantities as to get the benefit of carload rates of freight.

Seventh: Finance resources by keeping material in as few places as possible, and in such shape that it is ready to move when required.

Eighth: Prompt and certain deliveries only in such quantities as are actually needed.

Ninth: Keep only a minimum amount of material on hand.—*H. C. Pearce before the Railway Storekeepers' Association.*

LARGE FRENCH METAL WORKING PLANT.—The Creusot works of Schneider & Company in France occupy an area of about 3,300 acres and extend uninterruptedly for a distance of three miles. The different departments are connected by a system of railways 200 miles in length, with a rolling stock of 55 locomotives and 1,600 cars. The number of employees of all classes varies from 15,500 to 16,000.—*American Machinist.*

EXHAUSTION OF OUR COAL SUPPLY.—The exhaustion of our coal supply is not in the indefinite future. The startling feature of our coal production is not so much the magnitude of the annual output as its rate of growth. For the decade ending in 1905 the total product was 2,832,402,746 tons, which is almost exactly one-half the total product previously mined in this country. For the year 1906 the output was 414,000,000 tons, an increase of 46 per cent. on the average annual yield of the ten years preceding. In 1907 our production reached 470,000,000 tons. Fifty years ago the annual per capita production was little more than one quarter of a ton. It is now about five tons. Estimates of coal deposits still remaining must necessarily be somewhat vague. The best authorities do not rate them at much over 2,000,000,000,000 tons. If coal production continues to increase as it has in the last ninety years, the available supply will be greatly reduced by the close of the century. Before that time arrives, however, resort to lower grades and sinking of mines to greater depths will become necessary, making the product inferior in quality and higher in price.—*James J. Hill before the Governors' Conference.*

WHAT THE RAILROAD CLUBS WILL DO IN SEPTEMBER.

Canadian Railway Club (Montreal).—R. E. Johnson, of the Canadian Fairbanks Company, Montreal, will present a paper on "Gas Producer Plants," September 1st, at the Windsor Hotel. Secretary, Jas. Powell, P. O. Box 7, St. Lambert, near Montreal.

Central Railway Club (Buffalo, N. Y.).—W. H. Evans, master mechanic of the International Railway Company, will read a paper on "Electric Traction vs. Steam Railroad Operation," Friday, September 11th. This is also the date of the fall outing of the club. A boat trip will be taken down the Niagara River, leaving at 10 A. M., and dinner will be served on Grand Island at 2:30 P. M. The return boat will reach the city at 7 P. M. The regular meeting of the club will be held on the boat en route. Secretary, Harry D. Vought, 62 Liberty street, New York City.

**Iowa Railway Club (Des Moines, Ia.)*—Meets September 11. Secretary, W. B. Harrison, Union Station, Des Moines, Ia.

New England Railroad Club (Boston).—Next regular meeting October 13th. Secretary, George H. Frazier, 10 Oliver street, Boston, Mass.

New York Railroad Club (New York City).—Raffe Emerson, assistant engineer of methods, Atchison, Topeka & Santa Fe Railway, will present a paper on "Handling Locomotive Supplies; Value of Proper Handling of Supplies; Supply Costs and Accounting; Design of Items of Engine Equipments; Methods of Handling Supplies and Equipments; Results," Friday, September 18th, at the Engineering Societies Building, 29 W. 39th street. Secretary, Harry D. Vought, 62 Liberty street, New York City.

**Northern Railway Club (Duluth, Minn.).*—Meets September 25. Secretary, C. L. Kennedy, 401 West Superior street, Duluth, Minn.

North-West Railway Club.—This club, of Minneapolis and St. Paul, has discontinued its meetings for the present season.

**Railway Club of Pittsburgh (Pittsburgh).*—Meets September 25. Secretary, J. D. Conway, P. & L. E. R. R., Pittsburgh, Pa.

**Richmond Railroad Club (Richmond, Va.).*—Meets September 10. Secretary, F. O. Robinson, 8th and Main streets, Richmond, Va.

**Rocky Mountain Railway Club (Denver, Colo.).*—Meets September 8th. Secretary, M. M. Currier, Box 220, Colorado City, Colo.

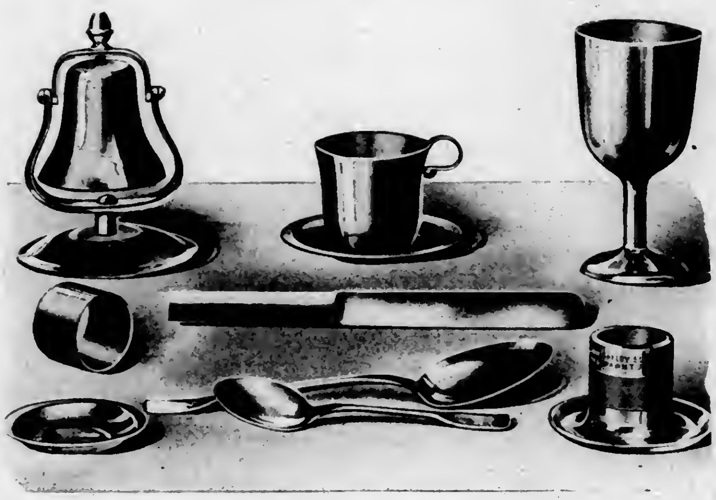
St. Louis Railway Club.—Prof. L. E. Young, director of the School of Mines and Metallurgy, Rolla, Mo., will address the meeting, Friday, September 11th. The exact subject has not yet been announced. Secretary, B. W. Frauenthal, Union Station, St. Louis, Mo.

Western Railway Club (Chicago).—Arthur Hale, chairman of the car service committee of the American Railway Association, will address the club on Tuesday evening, September 15th. Secretary, J. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

*Subject for discussion apparently not yet determined as no reply was received from the secretary up to the time of going to press. It is assumed that there will be no change in the time of holding the regular meeting.

UNIQUE ADAPTATION OF SHELBY TUBING.

At a banquet, recently given to the officials of the National Tube Company at Pittsburg, the dishes used were formed (not cast) from Shelby seamless steel tubing. As shown in the illustration, the material was hammered flat for the knife blade and spoon handles, was curved in or out for the bowls of the spoons



and for the plate and saucer, was left in its original shape for the napkin ring, was expanded at one end into several times its original diameter for the goblet, and was formed into a bell. It is said that over three hundred uses have been found for this tubing, and new uses are constantly being added.

PERSONALS

R. E. Fulmer has been appointed master mechanic of the Tremont & Gulf Ry., with office at Eros, La.

The office of the superintendent of motive power of the Mexican National R. R. has been transferred from Laredo, Tex., to San Luis Potosi.

W. C. Hayes, superintendent of the Erie at Susquehanna, has been appointed superintendent of locomotive operation, with headquarters in New York.

H. E. Lind has been appointed storekeeper for the Erie R. R. at Susquehanna, Pa., vice T. H. Keffer, resigned. H. J. Ackworth succeeds Mr. Lind as storekeeper at Kent, O.

R. B. Smith has been appointed foreman of motive power and equipment of the Cincinnati, Lebanon & Northern Ry., at Rendleton, O., succeeding John Stutter, resigned.

William Henry, assistant master mechanic of the St. Louis & San Francisco R. R., at Memphis, Tenn., has been appointed master mechanic with headquarters at Sapulpa, Okla.

William Baird, general car inspector of the Chicago, Burlington & Quincy Ry., has been appointed shop superintendent at the Plattsmouth, Neb., shops, succeeding H. J. Helps, resigned.

W. Hamilton, acting locomotive foreman of the Grand Trunk Ry., at Palmerston, Ont., has been appointed locomotive foreman at Stratford, Ont., succeeding J. A. Mitchell, resigned.

J. A. Mitchell, locomotive foreman of the Grand Trunk at Stratford, Ont., has been appointed locomotive foreman of the Grand Trunk Pacific, with office at Rivers, Man.

C. E. Gossett, master mechanic of the Chicago, Rock Island & Pacific at Armourdale, Kan., has been appointed master mechanic of the Iowa Central, succeeding T. M. Feeley, resigned.

G. W. Taylor has resigned as division master mechanic of the Atchison, Topeka & Santa Fe Ry., at Newton, Kan., to become superintendent of motive power of the San Antonio & Aransas Pass Ry., with headquarters at San Antonio, Tex., succeeding G. W. Butcher, resigned.

J. H. Munro has been appointed locomotive foreman of the Canadian Pacific Ry. at Muskoha, Ont.

George Wagstaff, supervisor of boilers of the New York Central Lines, has resigned, effective September 1, on which date he will take service with the Railway Materials Co., of Chicago.

G. H. Davis, master mechanic of the Clarendon & Pittsford R. R., has been appointed general foreman of the car department of the Wabash Pittsburg Terminal, with headquarters at Rook, Pa.

E. V. Lea, instructor of apprentices at the Hornell, N. Y., shops of the Erie R. R., has been appointed assistant supervisor of apprentices of the entire Erie system, with headquarters at Meadville, Pa.

H. H. Hale, superintendent of motive power of the Nevada Railroad, has been appointed master mechanic of the Gulf & Ship Island Ry., with headquarters at Gulfport, Miss., succeeding W. J. Haynen, resigned.

W. B. Russell, assistant superintendent of apprentices of the New York Central Lines, has resigned to accept a position as director of the new technical school in Boston, known as the Franklin Union. Benjamin Franklin left 1,000 pounds to Boston and 1,000 pounds to Philadelphia, to be on interest for one hundred years, at the end of which time it was to be used for some public purpose. The money in Boston has been used for an industrial school, the building of which cost $375,000. The city provided the land and Andrew Carnegie presented an amount equal to the Franklin fund for an endowment to run the school. It is to be equipped as an industrial school and to run with evening classes for mechanics and others working during the day time. The school is a combination of Cooper and Mechanics' Institutes, New York, and Pratt Institute, Brooklyn, adapted to the special needs existing in Boston and vicinity. It will represent the very latest thing in industrial education. Henry Gardner, apprentice instructor at the McKees Rocks shops of the Pittsburgh & Lake Erie R. R., has been promoted to succeed Mr. Russell on the New York Central Lines.

POOR'S MANUAL FOR 1908.

Poor's Manual for 1908 (forty-first annual number) is issued. Although the work appears some two months earlier than last year and five months earlier than in 1906, yet it is as complete as ever, covering the 1907 fiscal year and calendar years, and containing information concerning the more important companies up to June 10, 1908.

An important feature of this edition is an enlarged industrial section embracing every prominent corporation in the United States from which a report could be obtained. Information is strictly up to date, and in the case of the larger companies include elaborate tables showing income accounts and balance sheets in comparative form for a series of years. In general treatment the industrial section compares favorably with the railroad section.

The total mileage of the steam railroads of the United States on December 31, 1907, was 228,128 miles, as against 222,766 miles on December 31, 1906, showing an increase of 5,362 miles.

The total capital liabilities of the railroads, including stock, bonds and other indebtedness, was $16,501,413,069, showing an increase of $907,864,112. Of this increase $351,717,809 is represented by stock and the balance by bonds and other forms of indebtedness.

The following table shows assets and liabilities of all the steam railroads of the United States at the close of 1907:

	1907.	1906.
Capital stock	$7,458,126,785	$7,106,408,976
Bonded debt	8,228,245,257	7,851,107,778
Other bond obligations	815,041,027	636,032,203
Accrued liabilities	94,938,347	86,218,524
Miscellaneous liabilities	75,450,828	124,319,942
Bills payable and col'c't accounts	857,734,167	722,023,502
Sinking funds, etc.	239,727,545	242,256,471
Profit and loss	789,617,481	686,919,232
Total liabiliites	$18,558,881,437	$17,455,286,628
Cost of railroad and equipment	$13,364,275,191	$12,719,736,342
Stocks and bonds owned	2,884,031,173	2,544,368,852
Real estate and other investments	738,843,199	761,413,476
Cash, bills rec. and col'c't acc'ts	979,730,908	941,399,320
Materials and supplies	224,237,534	182,635,253
Other assets	208,171,082	128,591,860
Sinking funds	159,592,350	177,141,525
Total assets	$18,558,881,437	$17,455,286,628

Gross earnings of the railroads reporting earnings for 1907, embracing 225,227 miles, amounted to $2,602,757,503, as compared with $2,346,640,286 in 1906, showing an increase of $256,117,217, or nearly 11 per cent. Net earnings from operation in 1907 were $833,839,600, as against $790,187,712 in 1906, showing an increase of $43,651,888, or about 5½ per cent. In 1906 net earnings had shown an increase of more than 15 per cent.

The following table shows the income account of the American railway systems for the year 1907, as compared with 1906:

	1907.	1906.
Miles of railroad operated	225,227	220,633
Passenger	$574,718,578	$521,231,337
Freight	1,825,061,858	1.659.925.643
Other	202,977,067	165,483,306
Total gross earnings	$2,602,757,503	$2,346,640,286
Operating expenses	1,769,417,903	1,556,452,574
Net earnings	833,339,600	790,187,712
Other receipts	128,015,081	100,292,369
Total net income	$961,354,681	$890,480,081
Taxes	74,253,245	68,169,833
Interest on bonds	280,931,001	269,926,395
Other interest	23,759,329	13,107,169
Dividends on stock	247,258,219	225,601,245
Miscellaneous	75,176,725	79,806,024
Rentals—interest	38,188,406	39,612,179
Dividends	31,087,374	27,739,680
Miscellaneous	18,127,456	15,042,783
Total payments	$788,781,755	$739,005,308
Surplus	$172,572,926	$151,474,773

Traffic Statistics.

	1907.	1906.
Miles of railroad operated	225,227	220,633
Revenue train mileage:		
Passenger	511,579,317	488,554,209
Freight	645,447,465	608,324,539
Mixed	27,211,527	27,711,651
Total	1,184,238,309	1,124,590,399
Passengers carried	885,724,314	815,774,118
Passenger mileage	28,370,247,819	25,842,462,029
Revenue per passenger-mile, cents	2.040	2.011
Tons freight moved	1,722,210,281	1,610,099,829
Freight mileage	233,137,507,807	216,653,795,696
Revenue per ton-mile, cents	0.782	0.766

BOOK NOTES.

Bulletin of Foundry Information. Volume 6. Bound in cloth. 160 pages. Published by The S. Obermayer Co., Cincinnati, O. Price, 60 cents.

This book consists of a year's issue of the *Obermayer Bulletin of Foundry Information,* which includes much information of value to foundrymen. The articles are written by men thoroughly familiar with their subjects and are strictly practical.

Binders for Coal Briquets. Report of investigations made at the fuel testing plant, St. Louis, Mo. By James E. Mills. Bulletin No. 343 of the United States Geological Survey, Department of the Interior, Washington, D. C. Can be obtained upon request.

This bulletin goes into the subject of binders for briquets in great detail and gives the results of the very valuable experiments which were made along these lines at the government's testing plant at St. Louis.

Reinforced Concrete. A Manual of Practice. By Ernest McCullough. 4½ x 7½ in.; 124 pages; illustrated. Published by the Cement Era Publishing Co., 842 Monadnock Block, Chicago, Ill. Price, $1.00.

This book is written for men not technically educated and gives practical instructions in the proper methods of procedure in the design and location of forms and the placing of the concrete. There is also some space given to the theoretical treat-

ment of reinforced concrete structures, all of which is, however, explained in simple language.

The Plane Table. By W. H. Lovell, Topographer, U. S. Geological Survey. Cloth. 47 pages. 4½ x 7¼. Illustrated. Published by the McGraw Publishing Co., 239 W. 39th St., New York. Price, $1.00.

The plane table is one of the oldest of surveying instruments and possesses obvious advantages as regards speed, economy, convenience and adaptability for surveying purposes, but has been used to a very limited extent in this country. This small book points out the way in which this instrument can be made of greater value to surveyors.

Steel Car Design. By A. Stucki. 23 pages, 7 x 10, illustrated. Published by the author, Room 617, Farmers' Bank Building, Pittsburg, Pa. Price, $2.00.

Mr. Stucki has had a number of years' experience in the engineering departments of two of the large steel car companies, in addition to considerable actual railroad experience. The book consists of a reprint of a series of articles published in the *Railroad Gazette* during June and July, 1904. It is not intended to give a complete and absolutely accurate analysis of the stresses in steel cars, but consists of extracts from Mr. Stucki's note book based on his experience in designing and building cars and data from the testing laboratory.

Hand Book of Mathematics for Engineers. By L. A. Waterbury. Vest pocket size. 90 pages. Flexible leather cover. Published by John Wiley & Sons, 43 E. 19th street, New York. Price, $1.00.

This hand book is intended as a reference book for the use of those who have studied, or are studying, the branches of mathematics usually taught in engineering courses. It is not intended as a text book and therefore does not attempt to prove any of the formulæ which are given. The different subjects treated in this book are, algebra, trigonometry, analytic geometry, differential calculus, integral calculus, theoretical mechanics and mechanics of materials, the last being the largest section and covering the subject in all of its more important features.

Up-to-Date Air Brake Catechism. By Robert H. Blackall. Twenty-third edition. Revised and enlarged. 373 pages. Cloth. Illustrated. Published by the Norman W. Henley Publishing Company, 132 Nassau street, New York. Price, $2.00.

The improvement in air brake apparatus is so constant and important that necessarily any book which pretends to cover the subject thoroughly must be continuously revised and enlarged. A good example of this is the book under consideration, which was first brought out ten years ago, is now in its twenty-third edition, and has been revised five or six times during that period. It is undoubtedly the most complete and accurate work on the Westinghouse air brake system obtainable and, being arranged in catechism form, is of particular value to trainmen and others who are compelled to take examinations in this subject.

How to Become a Competent Motorman. By Virgil B. Livermore and James R. Williams. Second Edition; revised; 4½ x 6¼ in.; 247 pages; illustrated. Published by D. Van Nostrand Co., 23 Murray street, New York. Price, $1.00.

This book is written by two practical men who, by actual experience, have learned just which things a competent motorman must know. It deals with the subject in an elementary manner, being fully illustrated with half-tones of apparatus and diagrams of connections. It includes descriptions and instruction on the air brakes used on electric equipment, as well as considerable matter on signaling. Each section of the book contains a series of questions and answers such as would ordinarily be asked in an examination on the subject.

Notes on Hydro-Electric Developments. By Preston Player. 65 pages. 4½ x 7¼. Cloth. Published by the McGraw Publishing Company, 239 W. 39th St., New York. Price, $1.00.

This book confines itself to a consideration of the commercial side of the utilization of water power. Its primary object is to indicate, as far as possible, the information which should be obtained in order to afford a definite basis for forming a decision as to the merits of any proposed undertaking. The subject from this standpoint is treated clearly and accurately, and points out the exact conditions under which a certain proposition will or will not be profitable.

The Hill Kink Books. Compiled by F. H. Colvin and F. A. Stanley, associate editors of *The American Machinist*. Published by the Hill Publishing Company, 505 Pearl St., New York City. 4 x 6 in. Illustrated. About 100 pages each. Cloth bound. Price, 50 cents each.

There are ten of these little volumes as follows: Drill Press Kinks; Tool Makers' Kinks; Screw Thread Kinks; Jig and Fixture Kinks; Drawing Room Kinks; Patternmaking Kinks; Milling Machine Kinks; Screw Machine Kinks; Press Tool Kinks and Repair Kinks. The information has been carefully selected from the columns of *The American Machinist;* the editors make no pretense of trying to treat each subject exhaustively, but have tried to place within convenient reach of mechanics and draftsmen out of way information which it would be otherwise difficult to find quickly, or at all.

National Society for the Promotion of Industrial Education. Bulletin No. 5. Proceedings of the First Annual Meeting, Chicago; Part 1. Copies may be obtained by addressing the Secretary at the office of the Society, 546 Fifth avenue, New York City. Price, ten cents.

This bulletin contains the following addresses: "Industrial Education as an Essential Factor in Our National Prosperity," by Charles W. Elliott; "Industrial Education from the Standpoint of the Manufacturer," by James W. Van Cleave; "The Aims of the National Society for the Promotion of Industrial Education," by Henry S. Pritchett; "The Apprenticeship System as a Means of Promoting Industrial Efficiency," by Carroll D. Wright; "The Apprenticeship System of To-day," by W. R. Warner; "The Value of a Thorough Apprenticeship to the Wage Earner," by W. B. Prescott; "Trade Instruction in Large Establishments," by J. F. Deems, and "The Necessity of Apprenticeship," by Leslie W. Miller.

The Railroad Signal Dictionary. By Braman B. Adams and Rodney Hitt. 9 x 12 in.; 514 pages; 3,120 engravings. Published by the Railroad Age Gazette, New York, Chicago, Pittsburg and London. Bound in morocco. Price, $6.00.

The editors prepared this dictionary under the supervision of a committee of the Railway Signal Association. They thus had the benefit of all the resources of that association, also of the co-operation of the leading manufacturers of the country and of the *Railroad Age Gazette* office. The dictionary in many respects is similar to the car builders' and locomotive dictionaries, except that it is necessarily more complete in the description of processes and methods, because of the less advanced state of the art of signaling and its rapid development. The illustrations of every important machine or piece of apparatus are accompanied by a carefully prepared description of its working. It forms a complete and up-to-date treatise on signal engineering and is invaluable to anyone interested in that subject.

Railway Signaling. Written by a staff of expert signal engineers. 108 pages. 6 x 9. Cloth. Illustrated. Published by the Electric Journal, 422 6th Ave., Pittsburg, Pa. Price, 75 cents.

Anyone who has attempted to post himself on modern signaling apparatus has been greatly hampered by the lack of literature which shows the more recent and up-to-date appliances. The *Electric Journal* realized this condition and obtained a series of

articles from the engineers of the Union Switch and Signal Co., which ran serially. These articles have been put into book form and describe the various principles of operation and types of apparatus in a manner which places the information within the reach of the ordinary laymen. The book is thoroughly illustrated with half-tones and line drawings. It is divided into nine chapters, as follows: Mechanical Interlocking; Electro-Pneumatic Interlocking; Electric Interlocking; The Electric Train Staff System; Automatic Block Signaling; Automatic Block Signaling—Direct Current; two chapters on Automatic Block Signaling—Alternating Current; The Language of Fixed Signals.

CATALOGS WANTED.

F. H. Ely, chief engineer of the Corning, Keuka Lake and Ontario Railway Company, with offices in the Hudson Terminal Building, New York City, desires to secure catalogs of all classes of railway equipment, rolling stock, etc.

CATALOGS

IN WRITING FOR THESE PLEASE MENTION THIS JOURNAL.

Gisholt Tools.—The Gisholt Machine Company, Madison, Wis., is issuing a small size catalog containing 72 pages, which very completely illustrates and briefly describes the large variety of tools manufactured by it. This catalog will be found to be very convenient for ready reference.

Steam Turbines.—The Terry Steam Turbine Company, Hartford, Conn., is issuing a catalog illustrating and describing its type of turbine for driving dynamos, pumps, blowers, shafting, or machinery. The details of the construction are clearly illustrated and photographs of direct connected units of various kinds are shown.

College of Engineering, University of Illinois.—Bulletin No. 14 of the University of Illinois, Urbana, Ill., consists principally of a number of most interesting photographs, showing the buildings and equipment of the College of Engineering of that University. A brief mention of the purposes of the ten different courses, given in this college, is also included.

Graphite.—An interesting booklet has been received from the Joseph Dixon Crucible Company, Jersey City, N. J., entitled "Dixon's Ticonderoga Flake Graphite." It presents a brief discussion concerning graphite and its formation, and its value as a lubricant under different conditions of service. Copies of this booklet may be secured by writing direct to the Dixon Company.

Air Brake Instruction Books.—Instruction Book No. 5034, from the Westinghouse Air Brake Company, Pittsburg, Pa., describes in detail the construction and operation of the type L triple valve. Instruction pamphlets Nos. T-5037 and T-5035, from the Westinghouse Traction Brake Company, Pittsburg, Pa., describe respectively No. 12 EL locomotive brake equipment and its operation and the AMS brake equipment and its operation.

Asbestos and Magnesia for Railroads.—The H. W. Johns-Manville Co., 100 William street, New York, is issuing catalog No. 251, which is devoted to illustrating and describing the great variety of asbestos and magnesia products which are used on railroads. The catalog contains 180 pages and covers very fully practically all products of this kind which find a use for lagging pipes and boilers; packing flange joints, piston rods, etc.; cementing pipes; pipe and other gaskets, pump valves, etc.

Hart Convertible Cars.—The Rodger Ballast Car Company, Railway Exchange, Chicago, Ill., is sending out a booklet known as the reference book of 1908. It describes and illustrates, both with line drawings and half-tone reproductions, the Hart convertible car which is adapted for construction and maintenance purposes, and also as a general service gondola car. A number of convertible box and stock cars, flat cars, side dump cars, work cars and special cars are also illustrated.

Walschaert Valve Gear.—A pamphlet on this subject recently issued by the American Locomotive Company contains a paper read by C. O. Rogers, traveling engineer of the company, before the eighth biennial convention of the Brotherhood of Locomotive Engineers, at Columbus, Ohio, May, 1908. The purpose of the paper was to explain in a simple and plain manner the principle, action, and construction of the Walschaert valve gear, and the difference between it and the Stephenson link motion. One section, that containing suggestions and recommendations regarding what to do in case of breakdowns on the road, will in particular be of value to those operating engines equipped with this type of valve motion. A number of illustrations of engines, disconnected and blocked as recommended, are given to assist in a clear understanding of the text. A copy of the pamphlet will be mailed upon request.

Steam Gauges.—The American Steam Gauge and Valve Mfg. Co., 220 Camden street, Boston, Mass., is sending out a 120-page, standard size, catalog, which most thoroughly illustrates and describes the different lines of gauges made by them. In this catalog will be found a number of new arrangements and designs of gauges and allied apparatus. Calorimeters, thermometers, whistles, pyrometers and water columns are also given brief mention.

Electrical Apparatus.—The General Electric Company is issuing a number of new bulletins on various subjects, among which might be mentioned number 4597 on astatic switchboard instruments for continuous current. These instruments have no controlling springs and their accuracy is not affected by the changes of magnetic strength. No. 4575 describes type F form K7 oil switch, which has been designed to meet the requirements of induction motor installations. No. 4596 deals with the subject of globes for arc lamps. In addition to these a small circular, No. 3664, is being sent out which describes a new locking socket for preventing the removal of incandescent lamps by unauthorized persons. Due to the rapidly extending use of tantalum and other expensive lamps a socket of this kind is becoming a necessity.

Alundum.—A booklet of this title, published by the Norton Company, Worcester, Mass., tells in an interesting way of the various steps in the manufacture of this material. Alundum is used solely in the manufacture of Norton grinding wheels, and that it has given satisfactory service is indicated by the fact that in 1907 six million seven hundred and fifty thousand pounds were manufactured as against two hundred thousand pounds in 1901. Alundum is made by fusing bauxite in the intense heat of an electric arc furnace. This mineral is found in its purer forms in Georgia, Alabama and Arkansas, and the Norton Company controls its own supply from mines in these states. The bauxite is converted into alundum in the company's electric furnace plant at Niagara Falls and this is made into the finished product at the works in Worcester, Mass.

The booklet closes with a consideration of the properties possessed by alundum, which make it so satisfactory for grinding purposes, and directs forcible attention to the fact that the grade of the wheel should be adapted for the work which it is to do.

NOTES

Pittsburgh Emery Wheel Co.—This company has just finished an order of 55 emery wheels which have a 26 in. width of face. This is an exceedingly difficult proposition for manufacture and is the second order of this kind which has been successfully completed by this company.

American Locomotive Company.—This company has recently received orders from the Central Northern Railway of Argentine for ten 10-wheel freight locomotives and twenty Pacific type passenger locomotives; also from the Eastern British Columbia Railway Company for two consolidation freight locomotives.

American Steam Gauge & Valve Co.—E. H. Smith, formerly master mechanic of the Boston & Albany R. R., has accepted the position of railroad representative for the American Steam Gauge & Valve Manufacturing Company. He will make his headquarters at the company's general offices, 220 Camden street, Boston.

New Buildings at the University of Illinois.—A contract for a new building, forming part of the College of Engineering, and which will be occupied wholly by the Department of Physics, has recently been let by the trustees of the University of Illinois. This building with its equipment will cost $250,000 and is to be known as the Physics Building.

Warehouse for The S. Obermayer Company.—The constantly increasing trade of this company in and around Erie, Pa., has made it necessary to open a branch warehouse in that city. Mr. W. L. Scott is in charge, and a full line of foundry facings, core compounds, plumbago and blackings will be carried for the present; just as soon as conditions warrant, a complete line of other foundry facings and foundry supplies will be carried in stock.

Goldschmidt Thermit Company.—This company, of 90 West street, New York, is building a new machine shop and foundry, 34 x 90 feet in size, just back of the present factory in Jersey City. It is to be fitted up for the purpose of handling the extensive repair work, which is now being carried on at these works, to better advantage. Special attention will be paid to the rapid execution of the repairs to any wrought iron and steel sections not exceeding 2,000 pounds in weight.

French Brill Company Organized.—Compagnie J. G. Brill, 14 Place de Laborde, Paris, France, has been organized to handle the business of the J. G. Brill Company, Philadelphia, in France and Spain. A plant is to be established and the Brill trucks for those countries will be built by French workmen under French supervision and with French machinery. Brill trucks and equipment have become very popular throughout these two countries and it is believed that this business can be better handled by a complete plant in France.

CARE OF BOILERS AT TERMINALS

By J. F. Whiteford.*

One of the most perplexing problems that confront the operating department and especially the mechanical officials, is the handling of engines at terminals. When it is considered that fully thirty per cent. of the life of a locomotive is spent at roundhouses, as compared with eight per cent. at repair shops, and that roundhouse repairs constitute forty-five per cent. of their maintenance, the urgent need of adequate facilities and improved methods becomes very apparent, and the necessity of roundhouse improvements seems of more vital importance than repair shop facilities.

With the development of the locomotive to its present state of efficiency, the care of the boiler has become the most important item in roundhouse work, though investigation reveals the fact that, either through ignorance on the part of those handling this class of work, or lack of proper facilities, boilers are often tortured to the extreme. Economical operation demands that this question be given the utmost consideration and that not only proper tools and facilities be provided, but that proper methods be employed and efficient supervision installed to prevent the continuance of abuses that have become standard through extended practice.

The difference of opinion of those directly responsible for boiler performance, as to the proper methods to pursue, has in many instances proven a great obstacle in improving the service, and the real problem devolves upon those in immediate charge of the work, leaving them to use their own judgment in the matter, however correct or faulty it may be; the boiler suffers in consequence.

The differences in boiler design and specifications of boiler material are sufficient evidence as to the variation of opinions held and indicate the difficulty in outlining a method of handling boilers that will be entirely satisfactory to all concerned.

While the subject of boiler repairs is one which is deserving of much study, the writer has left this item for further consideration and wishes to direct special attention to the washing of boilers and to present views as to the best methods, deduced from careful experiment and continued investigation.

All authorities on metallurgy agree that when non-tempering steel is subjected to a change in temperature that the best results are obtained when care is taken to insure the heating or cooling to be as uniform as possible. Boiler men hold the same opinion, especially as applied to the annealing of fire box sheets previous to their application, and since it is essential to maintain a uniform temperature in handling a plate independently, it appears to be even more essential to do so after it has become a part of a locomotive boiler, where limitations of dimensions are such as to necessitate a very rigid construction, and internal strains induced by unequal temperatures will be unusually severe. It therefore becomes evident that the best method of handling boilers at terminals is the one wherein the temperatures of the various portions of the boiler are maintained uniform or nearly so; the accompanying charts illustrate the temperature variations during different operations.

For this purpose, several high grade thermometers were placed in various parts of the boiler and readings were taken simultaneously. As it was found that the temperatures were almost identical on the same levels, the charts include only those showing the temperatures at the crown sheet (Thermometer No. 1) and the mud ring (Thermometer No. 2), thus indicating the variation in temperatures in a vertical distance of forty-four inches.

Much has been written relative to damage resulting from the use of injectors when the engine is standing still. Exhibit A serves to give additional data on this point, since it shows the variation in temperatures resulting from the use of the injector while an engine was standing on the ash-pit track, awaiting its turn to be taken to the house. The rapid drop of the bottom thermometer to a point 112 degrees lower than the top one during a period of sixteen minutes is sufficient evidence to indicate that the care of a boiler at a terminal must begin immediately upon its arrival, more especially since the class of labor usually employed on this work fails to realize sufficiently the necessity of prompt handling.

Designers of terminals who neglect to provide adequate facilities for the elimination of ash-pit delays, even during periods of congestion, overlook a very important feature in economical operation, as provision should be made to handle engines promptly. The fire should either be knocked or cleaned, as the needs of the service require. It is very difficult to herd engines with dirty fires and the system of having engines cross the ash-pit in the order of their arrival permits a more efficient organization and tends to decrease boiler repairs.

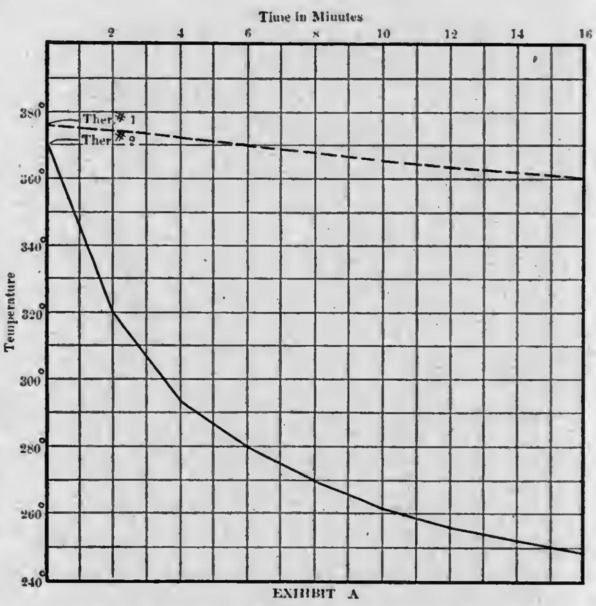


EXHIBIT A

VARIATION IN BOILER TEMPERATURES RESULTING FROM USE OF INJECTOR WHILE ENGINE WAS STANDING ON ASH PIT TRACK AWAITING ITS TURN TO BE TAKEN INTO THE ROUNDHOUSE.

The cooling of a boiler preparatory to the washing or changing of the water is the next important operation and charts are given showing the temperatures during the cooling by the following methods:

Exhibit B—Cooling with 60 degree water.

Exhibit C—Cooling with 125 degree water.

Exhibit D—Blowing out without cooling.

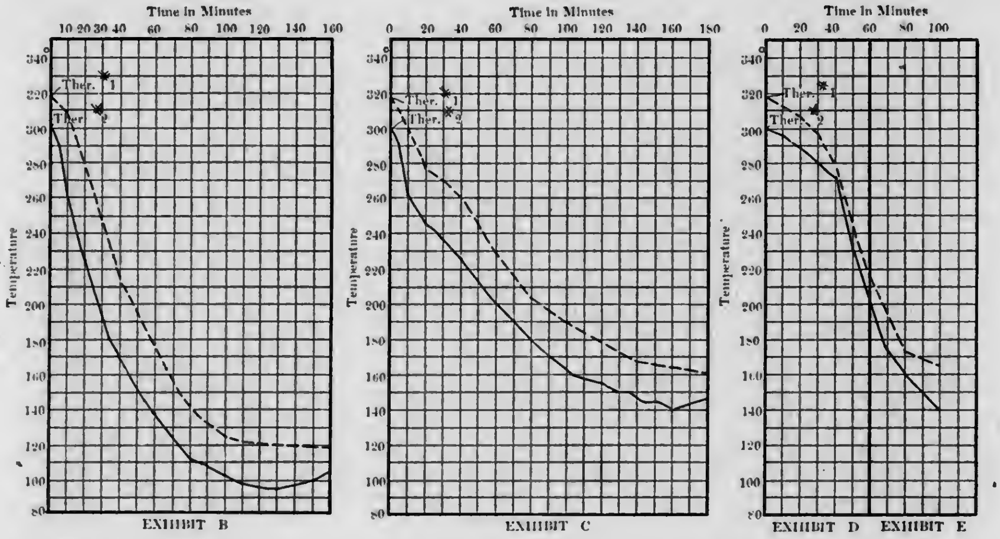
In all cases, the pressure was reduced to 75 pounds by blowing the steam off through a dome connection into an overhead line, and the cooling water in both Exhibits B and C was introduced through the branch pipe and injector throttle.

With the introduction of 60 degree water for cooling purposes (Exhibit B), a comparatively even and gradual reduction in temperature was realized, the maximum difference in the readings being 62 degrees at the twenty-minute line; the total time necessary to reduce the temperature from 320 degrees to 116 degrees was 160 minutes.

When water at 125 degrees was introduced (Exhibit C), the reduction in temperature was slightly irregular, though with less variation as compared with Exhibit B and considerably slower, since a total of 180 minutes elapsed in reducing the temperature from 315 degrees to 160 degrees with a maximum difference of 34 degrees at the forty-minute line.

In the third operation (Exhibit D), both blow-off cocks were opened and the contents of the boiler blown into a reservoir through suitable pipe, every effort being made to empty the boiler as rapidly as possible. The difference between the thermometers at the beginning was eighteen degrees, this gradually lessening to five degrees at the forty-minute line and continuing very near to that figure until the boiler was emptied, the temperature of both thermometers being approximately 210 degrees

* Member, American Society of Mechanical Engineers.



RESULTS OF COOLING THE BOILER UNDER DIFFERENT CONDITIONS: EXHIBIT B, WITH WATER AT 60 DEGS. F.; EXHIBIT C, WITH WATER AT 125 DEGS. F.; EXHIBIT D, BLOWING OUT WITHOUT COOLING.

at that time. This chart clearly illustrates that the least variation in temperatures is accomplished by simply blowing the contents out of the boiler as rapidly as possible and that the boiler is ready for washing fully ninety minutes earlier than by the method shown in Exhibit B.

In connection with this operation, Exhibit E is shown illustrating the temperature readings while the boiler was being washed with water heated to 125 degrees. It shows the rapid decrease of sheet temperatures during this operation, the variations remaining almost constant until near the close. The difference of twenty-five degrees between the thermometers at the one-hundred-minute line is due to the mud ring and lower portion of the fire box being washed last; the crown sheet temperature would not drop as rapidly in consequence.

Great care should be observed in taking the readings during this operation as the proximity of the washing nozzle to the tnermometer will cause a temporary drop and readings should be taken so as to secure as nearly an average figure as possible.

The temperatures of the washing of the boilers are omitted in Exhibits B and C as the changes are comparatively slight and are not sufficient to enter into the discussion, while the length of time necessary in either of the three cases mentioned is dependent entirely on the condition of the boiler and need not be considered.

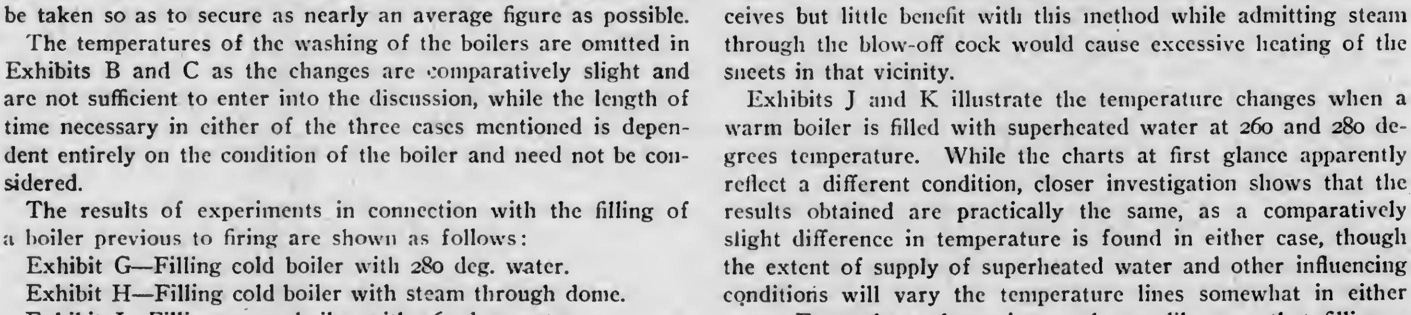
The results of experiments in connection with the filling of a boiler previous to firing are shown as follows:

Exhibit G—Filling cold boiler with 280 deg. water.
Exhibit H—Filling cold boiler with steam through dome.
Exhibit J—Filling warm boiler with 260 deg. water.
Exhibit K—Filling warm boiler with 280 deg. water.

For the purpose of comparison the charts cover a period of twenty minutes and are in most cases self-explanatory; special attention, however, is called to Exhibits G and H. In the former, where a cold boiler is filled with superheated water of 280 degrees temperature, the rise is very rapid to the six-minute line; a comparatively uniform condition follows though a drop in temperature of No. 1 is shown until a variation of 64 degrees is reached at fourteen minutes; this decreases rapidly thereafter. It should be noted that Thermometer No. 2 shows a more even temperature throughout; the crown sheet (Thermometer No. 1) remains at a much lower temperature than the mud ring during the operation.

Where a cold boiler is filled with steam through the dome (Exhibit H), a marked difference in temperature is shown between the crown sheet and mud ring, reaching 130 degrees at the eight-minute line and continuing throughout the operation. This chart is sufficient evidence against following this practice regardless of conditions, as the bottom portion of the boiler receives but little benefit with this method while admitting steam through the blow-off cock would cause excessive heating of the sneets in that vicinity.

Exhibits J and K illustrate the temperature changes when a warm boiler is filled with superheated water at 260 and 280 degrees temperature. While the charts at first glance apparently reflect a different condition, closer investigation shows that the results obtained are practically the same, as a comparatively slight difference in temperature is found in either case, though the extent of supply of superheated water and other influencing conditions will vary the temperature lines somewhat in either case. From these charts it may be readily seen that filling a boiler with superheated water at 260 or 280 degrees temperature gives a very satisfactory condition as regards uniformity of tem-



FILLING THE BOILER UNDER DIFFERENT CONDITIONS: EXHIBIT G, PUTTING WATER AT 280 DEGS. F. INTO A COLD BOILER; EXHIBIT H, FILLING A COLD BOILER WITH STEAM THROUGH THE DOME; EXHIBIT J, FILLING A WARM BOILER WITH WATER AT 260 DEGS. F.; EXHIBIT K, FILLING A WARM BOILER WITH WATER AT 280 DEGS. F.

perature, especially when the boiler is handled with sufficient rapidity so as to fill it before it cools to the temperature of the surrounding atmosphere.

The last and most important operation is that of firing up; the following charts illustrate the temperature lines during this period with varied conditions:

Exhibit L—Firing up with boiler filled with 60 degree water and no blower used.

Exhibit M—Firing as in Exhibit L, except blower used.

Exhibit N—Firing as in Exhibit M, except oil burning engine.

Exhibit P—Firing boiler filled with 260 degree water.

In these charts but little explanation is necessary with the exception that Exhibits L, M and P refer to coal burning locomotives and Exhibit N to an oil burner.

The extended periods where the variation in temperatures was over 120 degrees in Exhibits L and M, is worthy of much consideration as it indicates the internal strains that take place in a boiler during the firing up operation. While the variations are approximately the same in either case, it should be noted that where the blower was used (Exhibit M) and special effort was made to hasten the operation, that the duration was considerably less, the entire operation consuming 120 minutes against 240 minutes where no effort was made. This proves conclusively that it is an advantage rather than a disadvantage to hasten the firing operation, as a saving of time is accomplished and the period of inequalities of temperature is shortened considerably.

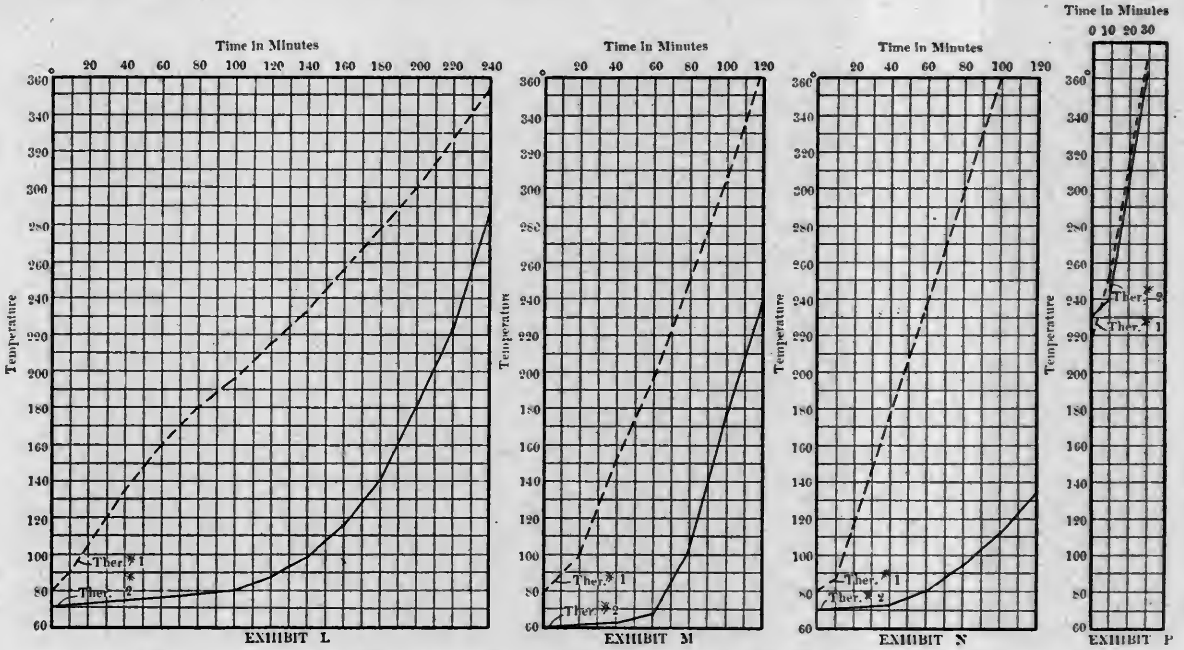
Exhibit N shows the temperatures during the firing up operation of a locomotive burning crude oil, in which case the blower was used and an effort was made to hasten the operation, the pressure being raised to 100 lbs. in practically 90 minutes. The extraordinary variation, reaching at times as high as 240 degrees, is largely due to the use of oil as a fuel and the arrangement of the brick work in fire boxes of this type, retarding circulation during this period.

The firing up of a boiler filled with superheated water at 260 degrees (Exhibit P) consumes from twenty-five to thirty minutes, during which time the temperature at the crown sheet raises from 222 degrees to 360 degrees, and at the mud ring from 230 degrees to 355 degrees, the variation of temperatures being less than ten degrees at all times.

In connection with this operation, it should be noted that when a boiler is filled with superheated water at a temperature of not less than 260 degrees, there should be an accumulated pressure when filling is completed to be utilized for blower purposes. As the use of the engine blower assists materially in inducing circulation throughout the boiler, the use of the accumulated pressure for this purpose minimizes the inequalities in temperature and consequently lessens the time necessary to complete the operation. This feature is of considerable importance, for if the water is superheated sufficiently, *i. e.*, to approximately 280 degrees, the regular house blower line can be dispensed with entirely.

The conclusions to be drawn from the foregoing experiments are that whatever means can be employed to hasten the handling of a boiler, the more efficient the service. The cooling down and firing up operations are the only ones necessary to consider and by studying Exhibits B and L, it will be noted that, by the cold water method, a variation from forty to sixty degrees exists in the first operation and from 100 to 140 degrees in the last operation; in both cases the period of unequal temperatures is quite extended; the total time consumed in performing these operations is 400 minutes.

By substituting Exhibit M for L, the total time for the two operations is reduced to 280 minutes, though the inequalities of temperature are much in evidence, the duration being considerably less through the use of the house and engine blower.



RESULTS OF FIRING UP UNDER VARIED CONDITIONS: EXHIBIT L, WITH THE BOILER FILLED WITH WATER AT 60 DEGS. F., NOT USING THE BLOWER; EXHIBIT M, SAME AS EXHIBIT L, EXCEPT THAT BLOWER WAS USED; EXHIBIT N, SAME AS EXHIBIT M, EXCEPT THAT THE ENGINE WAS AN OIL BURNER; EXHIBIT P, FIRING UP WITH THE WATER IN THE BOILER AT 260 DEGS. F.

In the hot water process (Exhibits D and P), the variation in temperatures does not exceed ten degrees except for very brief periods and the total time consumed is ninety minutes, showing a saving in time of 190 minutes in cooling down and firing up over the cold water method and at the same time reducing the internal strains to a minimum.

The full advantages of the hot water method may be outlined as follows:

Reduction in time out of service.

Reduction of water and fuel consumed.

Reduction of labor cost.

Reduction of boiler repairs.

On the average, about 7,500 gallons of water are used in cooling a boiler as outlined in Exhibit B, and 2,500 gallons in washing the boiler. By arranging for the treating or filtering of the contents of the boiler after it has been emptied into a sump, the water can be used for the purpose of washing so that approximately 10,000 gallons of water can be saved for each washout. With the cost of water at five cents per thousand gallons, the saving will be comparatively small, though where the water supply is limited and reaches forty cents per thousand gallons, this feature will be of considerable importance.

Under the average conditions, the firing operation as shown in Exhibit M will consume about 3,000 pounds of coal and that

shown in Exhibit P will consume approximately 1,500 pounds, though both of these figures could be reduced somewhat by close application on the part of the employee. However, in the ordinary run, 1,500 pounds of coal will be saved at each operation, and assuming the value at $1.35 per ton, a net saving of $1.00 can be realized per engine.

Owing to the variation of operating conditions and the influence they exert upon boiler repairs, it is an exceedingly difficult matter to determine the exact decrease in repairs due to the use of a hot water system, or the net saving which results directly in this item. It is safe to assume that a 40 per cent. reduction in boiler repairs can be realized and that the mileage between shoppings can be increased fully 30 per cent. in many instances, though these figures must of necessity be modified to suit local conditions.

Though the conserving of water and the saving of fuel are items of some importance, as is the reduction in boiler repairs and decrease of boiler failures, neither of these items are deserving of consideration as compared with the reduction of the time out of service. To properly cool and wash and fire an engine with the cold water method, under the average conditions, will consume from six to seven hours, while the same operations with a hot water system can be completed in not to exceed two and one-half hours, resulting in a saving of time of fully four hours per engine. Assuming 600 boilers handled at a terminal in one month, a total saving of 2,400 hours can be realized, the monetary value of which can only be estimated by the needs of the service, though an average value of $3.00 per hour can be used for comparative purposes.

The cost of facilities for handling boilers in the manner just described depends largely upon the requirements and local conditions, but when the reduction of time in handling engines is considered, together with the saving of fuel and water and decrease in boiler repairs, it would be a profitable investment at any terminal handling an average of six boilers and over a day.

A reduction of time held at terminals permits the same tonnage to be handled over a division with less locomotives and also permits more engines to be handled with the same roundhouse capacity. This item is worthy of much consideration as the total expenditure for facilities of this nature would be considerably less than that needed to provide additional roundhouse room, where growth of business demanded it under the old conditions.

Where complete facilities are not provided, much improvement in service can be effected by providing two sumps, the foul water to be discharged into one for filtration, or treatment, and the filling water heated in the other by the live steam discharged from engines that are blown down. This would enable boilers to be washed with water at 125 degrees, or even at 150 degrees, as washing water at the last named temperature can be used if due care is exercised by those handling it. The filling water could be heated and delivered to the boiler at a temperature dependent on the amount of waste heat that could be utilized, but from observation, at almost any terminal there is sufficient to furnish this water at not less than 200 degrees. This arrangement would also permit the exhaust from pumps and similar machinery to be utilized and permit a higher efficiency as regards fuel at the entire terminal.

As stated in the beginning of this article, there is a considerable difference of opinion among boiler men as to the handling of boilers and the following objections have been offered against the use of the hot water method of washing:

The difference between the temperatures of the washing water and the sheets is so great as to be detrimental to the structure of the steel. Experiments with non-tempering steel have shown that the metal can be heated to a temperature of 1,200 degrees Fahr. and quenched without affecting the structure of the steel, which would indicate that a variation of 100 to 120 degrees temperature could be permitted within the limits of good practice.

Another objection is that with the sudden cooling, there is a tendency for the sediment to bake into a scale upon the sheets, which impairs the efficiency of the boiler. It does not appear as though this condition could exist to any extent as the washing operation should follow so close upon the blowing out as to prevent scale forming to any degree and the hot water should have the effect of softening the scale more than cold water.

The scouring effect produced by blowing out the boiler under pressure has a marked tendency to clear the boiler of sediment, rather than allow it to collect around the stays, which action should leave a cleaner boiler than by the cold water method, and is an important argument in favor of the rapid cooling practice.

As to what reduction in pressure, if any, should be made by drawing off the live steam from the dome previous to opening the blow-off cocks must be governed entirely by the arrangement of facilities and local conditions. The discharge of water carrying much sediment under high pressure will cause excessive wear on the piping and fixtures, adding materially to the cost of maintenance, though the pressure should be sufficiently high to produce the cleansing effect above mentioned.

The maintaining of uniform temperatures throughout the boiler, accomplished by the blowing down without cooling, the washing with water at a temperature between 125 and 150 degrees, and the filling with superheated water at not less than 260 degrees will result in better boiler performance and consequently more economical operation, and these benefits can be realized by the conserving of energy now wasted at many terminals.

RAILROADS AND PROSPERITY.

The following is from an interview recently given by J. J. Hill to a New York *Herald* reporter:

"In no uncertain way have the railroads enabled us to make our country what it is to-day. They are pushing its prosperity and leading its progress as can no other single force. Yet, despite this record, they now are called upon to do the impossible. They are paying wages two and three times higher than the wage scales in other countries. They are employing equipment, in order to most effectively meet traffic demands, that costs one-third to one-half more than that used in other lands. They are facing constantly rising prices for materials. And, on the other hand, their rates are only one-third to one-half of the carrying charges of other countries—by far the lowest in the world. Our railroads have expended from $600,000,000 to $1,000,000,000 annually in recent years to improve their lines and keep them at the top notch of efficiency. The curtailment in business to-day is directly due to the curtailment of the buying power of the roads.

"In this contingency there is one step that must be taken if we are to have a return of general prosperity—freight rates must be moderately advanced. Justice demands that course and the best interests of the country at large require it. The alternative, the reducing of wages, is a dangerous expedient. Workmen need good wages to live properly. Cutting wages will not reduce the cost of living. Railroad operation requires good men. And the men who are handling the shuttling railroad trains today are the class of men upon whom the very life of this nation depends.

"If wages were cut there would be a breaking up of these organizations of loyal, earnest, dependable men, and many workingmen of sterling value would be lost. These men have a right to good wages. Surely it would be a dangerous expedient to step in and cut the wage scales in the face of the increased cost of living that controls to-day."

Effect of Water Soaking Timber.—Writers on wood seasoning mention the merits of lumber sawed from logs which have been submerged, directing special attention to the distinct advantages gained by soaking the logs or the sawed lumber in water, as a preliminary step to water seasoning. The United States Department of Agriculture advises that while soaking does decrease the tendency to warp it does not overcome the difficulty entirely. As a commercial practice it is not to be recommended except where it can be done during storage or transportation, because of the time required to produce results that fall far short of what is usually claimed.

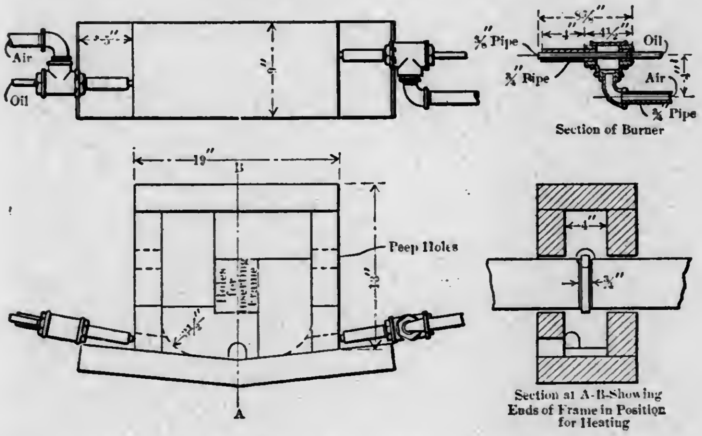
WELDING LOCOMOTIVE FRAMES.*

BY A. W. McCASLIN.

On the Pittsburgh & Lake Erie Railroad we repair some of the engine frames, as many others do, without removing them from the engine and, as far as superficial examination of the completed job would indicate, we have very good results. I do not say that we weld these frames, for, like Mr. Uren, I do not consider that such an operation, made without a lap of some kind, deserves the name weld. In fact, this butting of frames is simply a burlesque on proper welding. I have satisfied myself as to the virtue of this so-called weld by making several in the shop, granting them many advantages that cannot be offered on an engine, and have found that they would invariably separate, showing very little resistance to a light crosswise blow under a small steam hammer. The breaks show that a union of the metal had been effected, but also show a very feeble tenacity; yet, knowing these facts, we are very much in favor of repairing frames this way, wherever it is possible to spread the frame and take the heat, as it frequently keeps the engine in service until the time comes for general repairs, and this means quite a saving.

We have what we think are splendid burners, and build a very satisfactory furnace with standard size fire brick. Mr. Shoenberger, foreman blacksmith in the Ft. Wayne shop at Pittsburg, kindly furnished me the original design for both of them. They are illustrated in the sketch. I build the furnace with the bottom inclined as shown on blue print, making it about 1 in. lower at its center than at the fuel holes at the ends. Have also added a small slag hole at the center near the bottom, so the slag will not gather and be blown up against the frame. We use two burners, and crude and carbon oil as fuel, and take a very slow heat. The bottom, inclined as mentioned, helps to prevent the wasting of the bottom side of the frame and gives the heat a start to return over the top of the frame and out the peep hole. When the heat is complete the furnace is pushed into the pit and the work completed with light sledges.

I do not approve of making the side V weld under a heavy steam hammer without using a channel tool. The work will be satisfactorily performed, however, if done under a small steam

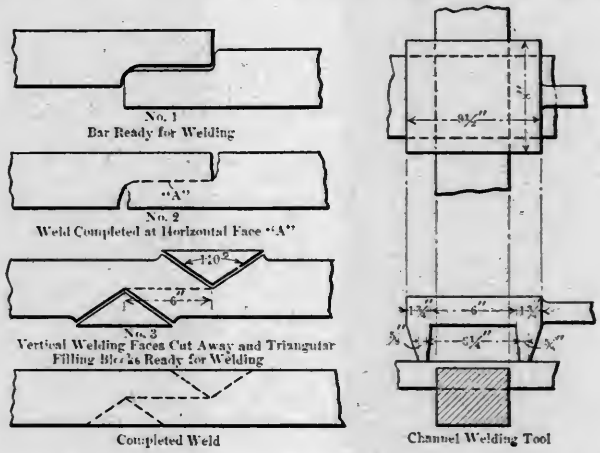


FURNACE AND BURNER FOR WELDING LOCOMOTIVE FRAMES.

hammer with light blows, or with heavy sledges. In this case the laid in piece should not be made with the overhang cut too close to the frame. Side heats should be drawn well up to the point of the V piece, and this stock driven back into the weld, at the same time a lap being formed where it is much needed, that is, at the ends of weld on the top and bottom of the frame.

If the side V weld is made in a frame under a heavy steam hammer there should be a heavy channel tool placed on top. This tool should be 8 in. wide, 2½ in. deep, and ½ in. longer in the crown, and ¾ in. longer at the mouth than the cross section of the frame, that it may release readily. It will shear off the extra stock, prevent the laid in piece from lengthening endwise, will drive it back into the weld, thus forcing it against the walls of the V, and lengthen the lap lengthwise the frame. A second heat should be taken on the laps, in order that there may be no hole or opening at the points of the weld. This is not only the most convenient weld to make in repairing frames, but it is the best.

We sometimes make, in front sections of frames and in large hammer piston rods, what we call a lap and V weld; we flatten the end of each piece nearly one-third, make the lap and weld



LAP AND V WELDS AND CHANNEL TOOL FOR HEAVY HAMMER WORK.

as shown on the sketch, then drive back the end of the laps and lay in a V; this insures a solid center and a solid side opposite each V. It also throws the laid in pieces about 6 in. apart. This weld will elongate evenly when being reduced and will not slip or shear as the ordinary lap or V weld will. The drawing clearly shows how this type of weld is made.

* From a paper presented at the recent meeting of the International Railroad Master Blacksmiths' Association.

LOCOMOTIVE REPAIR COSTS PER MILE.—In consequence of general shop inefficiency and operation inefficiency due to similar causes, locomotive repair costs on Western railroads run from $0.08 to $0.12 a mile; yet a most efficient superintendent of motive power on a large transcontinental road succeeded in dropping to $0.05 and had only touched the high spots, his well considered opinion being that $0.04 was reasonably attainable. On another transcontinental road, repair costs per mile were dropped from $0.1374 to $0.08 by persistent effort, but when the efforts were relaxed expenses immediately rose to $0.17. They should have come down to $0.06. Eastern and Southern roads, with their small engines, better coals, and better waters, are not to imagine that they show any higher efficiency. They are on the whole worse.—*Harrington Emerson in The Engineering Magazine.*

EXPERIENCE AS A TEACHER.—A great deal used to be said about learning from experience, because then there was no other source of learning, text books were very few and of a very poor quality, as their grammatical construction was more carefully looked after than their mechanical accuracy. Nowadays text books and instruction books are so numerous as to almost crowd up against you. Experience as the only teacher is only a poor excuse today. A railroad man cannot live long enough to experience all the breakdowns that can happen to a locomotive. The man who raises the loudest hurrah for experience as the only teacher generally suffers most from his method in his early schooling, for his "experience consists in having an engine break down and tie up the road for a time and then after the investigation serving from ten to thirty days for a lack of knowing how."—*C. B. Conger before the Traveling Engineers' Association.*

The number of miles of railroad per one hundred square miles of territory for the United States, June 30, 1906, was 7.55 as against 7.34 for the previous year.

THE DYNAMICS OF LOCOMOTIVE MACHINERY

By "G. E."

The object of this investigation was to apply to the locomotive certain mathematical processes employed in other engineering work, to see if they would bring out any new, valuable, or interesting facts. It is believed that the results are of interest, and that they throw some light on the behavior of certain locomotive details.

The locomotive described below will be considered in this investigation:

Type	Pacific
Cylinders	21 in. × 26 in.
Driving wheels	73 in. diameter
Boiler pressure	200 lbs. per sq. in.
Transverse spacing of cylinder centers	88 in.
Transverse spacing of frame centers	44 in.
Transverse spacing of counterbalance centers	63 in.
Transverse spacing of parallel rod centers	77 in.
Length of main connecting rod	128 in.

When the engine is exerting the maximum drawbar pull at slow speed, it will show an indicator card similar to that in Fig. 1. At any point of the stroke the effective force that moves the piston is equal to the difference between the pressures on the two sides; that is, the difference between the pressure of the admission, or the expansion line of the diagram, for one end of the cylinder and the back-pressure of the exhaust, or the compression line, of the other diagram at the corresponding points. If, then, the upper part of one diagram is combined with the lower part of the other, with due allowance for the area of the piston-rod section, the resulting figure shows the effective pressure for one stroke. Fig. 2 shows such a diagram, which we will call a stroke card, worked out from the indicator card in Fig. 1.

Following the action of the force resulting from this effective pressure we find that it is transmitted directly to the crosshead wrist-pin, where it is resolved into two components, one acting along the main rod and the other constituting a vertical pressure on the guides. This latter is at its maximum—about 7,000 lbs.—when the crank is on the quarter. Its recurrence alternately on the two sides of the engine causes the very noticeable rocking of the machine when working hard at slow speed.

Following the other component back to the vertical center line of the main driving-wheels, it resolves into vertical and horizontal components. The vertical one is just equal to the crosshead pressure on the guides, and represents an increase in "weight" at the main drivers in going forward and a decrease in backing. *This is one of the reasons why most types of engines are less likely to slip their drivers in going forward than in backing.*

Fig. 3 shows a method of determining the pressures of the driving-boxes against the shoes and wedges. In this case the three boxes on each side of the engine are treated as one, and so the pressures found are the sums for the three boxes. A B and C D are the driving wheels, E and F are the centers of the journals, K is the middle point of A C, G and L are the points where the center lines of the main connecting rods, extended if necessary, intersect the vertical, transverse plane of the center line of the axle. Moments are taken about the line E K, the forces being the horizontal components of the crank-pin pressures above referred to, and there is found the pressure at F required to balance those at the crank-pins.

These pressures are plotted in Fig. 4, as are also the sum of the net cylinder-head pressures for the two sides of the engine. The algebraic sum of these is the force that is transmitted through the frames to the foot plate, and (neglecting friction and wind resistance) becomes the tractive force of the engine, which, also, is plotted in Fig. 4. It has the familiar form of the tractive-force curve, and *explains why the driving wheels are most likely to slip when the crank angle is about 45 or 135 degrees.* The straight, horizontal line drawn at the average height of the tractive-force line is the average tractive force, or the tractive-force that is obtained by application of the usual formula to the mean effective pressure of the indicator card.

The tractive force is shown to be but a small balance of the enormous forces that act through the frame. For example, in this case, with a tractive force of but little over 30,000 lbs., the driving-box pressures produce a compression of 153,000 lbs. in the left-hand frame, between the cylinder and the front driver. *When it is remembered that this is an alternating stress and that a slight eccentricity of its resultant can produce a maximum intensity of stress as great as five or six times the average, the severity of the service on some frames is apparent. It is evident, too, that the stresses in electric-locomotive frames are entirely different, and their design should not be based on steam locomotive practice.*

If there is any pound in the boxes, it takes place where the curves of driving-box pressure cross the line of zero pressure. At the point of crossing on the right-hand side the pressure increases instantly to a greater pressure than is similarly reached on the left-hand side. *This provides an explanation for the more frequent breakage of frames on the right side than on the left, which is believed to be the common observation.* Of course, if the left crank leads, the opposite condition will result.

At high speeds the inertia of the revolving and reciprocating parts has to be considered. Fig. 5 shows a graphical method of doing this, which is derived from a combination of methods given by Professor Klein and by Mr. Wilfred Lewis. The full lines are the essential ones, and the dotted lines apply only to the proof, which is given in the appendix. O is the center of the driving wheel, O C the crank, C W the connecting rod, and H the center of percussion of the connecting rod. O A is perpendicular to the line of centers OW, and the arc to tCp is drawn on CW as a diameter. Arc tAp is drawn through A, about the center C. Lines $t\ p$ S and CS are drawn through points already located. HI is drawn parallel to OW, and IK, CN, and LM are perpendicular to OW. RN is made equal to OR, and WN is drawn. WA', perpendicular to OW, is made equal to OA and CA' is drawn. Let r represent the length of the crank and v its angular velocity. Then

(OA) $\times\ v =$ velocity of W.

(GL) $\times\ v =$ component of the velocity of H in the direction of the line of dead points.

(GM) $\times\ v =$ component of the velocity of H in the direction perpendicular to the line of dead points.

(OC) $\times\ v^2 =$ acceleration of the crank-pin in magnitude and direction.

(OS) $\times\ v^2 =$ acceleration of W.

(O I) $\times\ v^2 =$ acceleration of H, and (IK) $\times\ v^2$ and (OK) $\times\ v^2$ its components parallel and perpendicular respectively to the line of dead points.

Consider the engine running at 60.5 miles per hour and giving the indicator card shown in Fig. 6. The corresponding stroke cards are given in Figs. 7 and 8.

The main rod, when swung as a pendulum on a knife-edge passing through the center of the forward bearing, makes 36 single oscillations per minute. The length of the equivalent simple pendulum, or the distance from the center of the forward bearing to the center of percussion, is, therefore, 108½ inches. Divide the weight of the rod into two parts, one concentrated at the center of percussion and the other at the center of the forward bearing, and so proportion those parts that the location of the center of gravity of the rod will not be altered. Then the moment of inertia of the rod will not be altered, and the effects of the inertia of the rod on all other parts will remain unchanged. The weight at the center of percussion will be the total weight of the rod multiplied by the ratio of the distance of the center of gravity from the front bearing to that of the center of percussion from the same point. The remaining weight

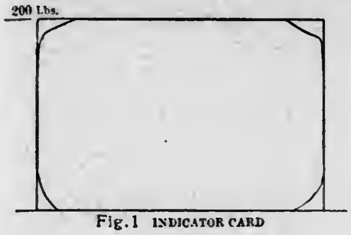


Fig. 1 INDICATOR CARD

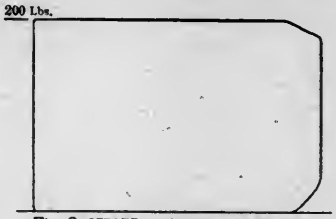


Fig. 2 STROKE CARD, OUTWARD STROKE

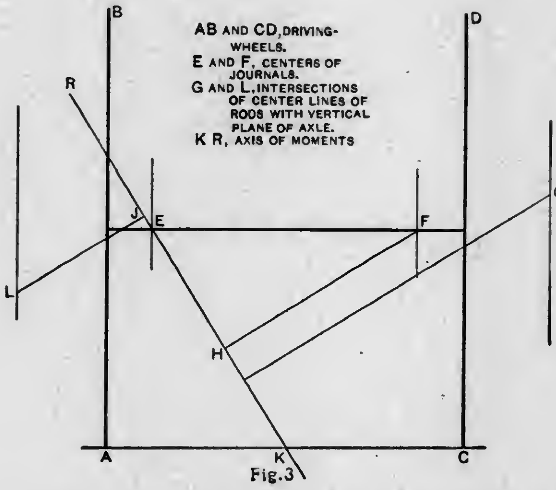


FIG. 3.—DRIVING-WHEEL MOMENT DIAGRAM, SHOWING METHOD OF DETERMINING PRESSURES OF DRIVING BOXES AGAINST SHOES AND WEDGES.

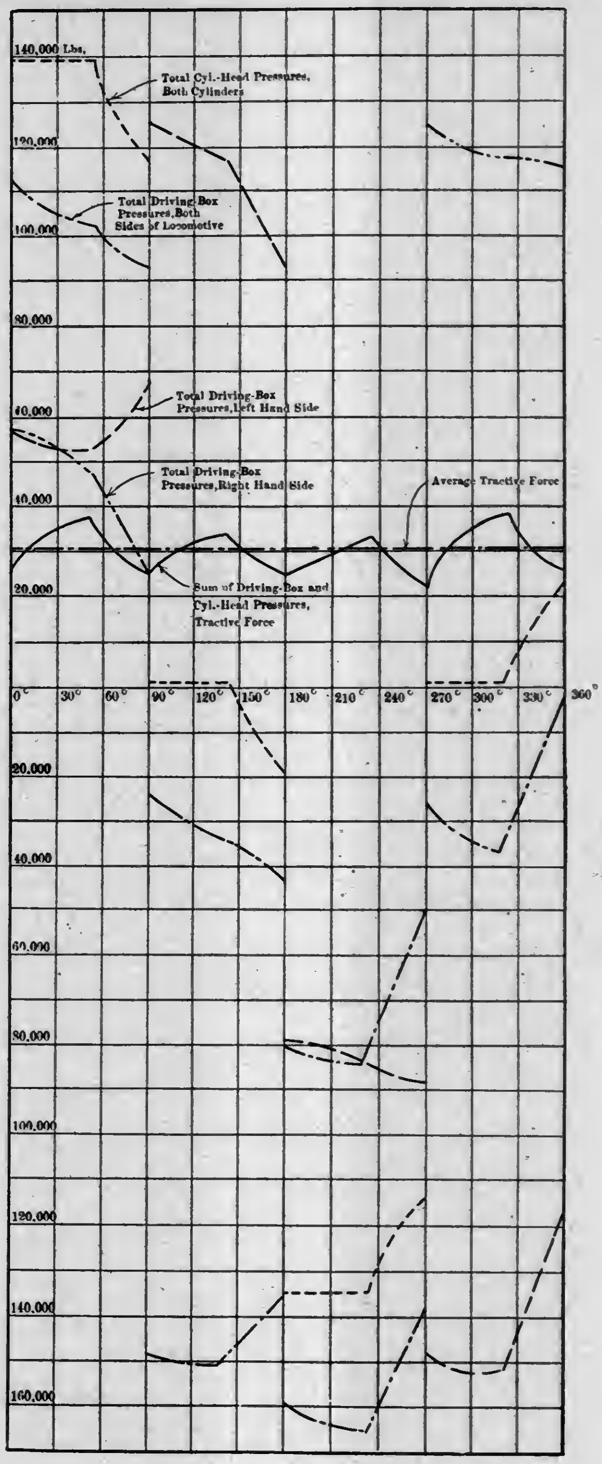


FIG. 4.

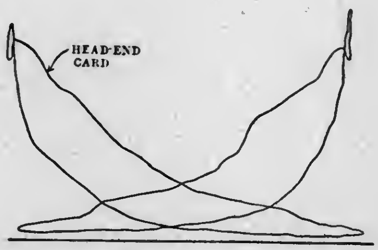
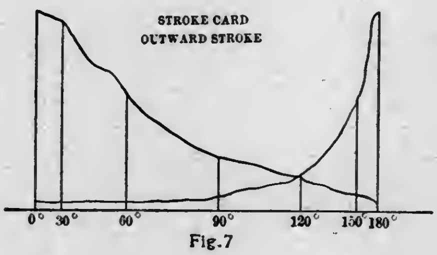


FIG. 6.—INDICATOR CARD TAKEN WHILE LOCOMOTIVE WAS RUNNING AT A SPEED OF 60.5 MILES PER HOUR.



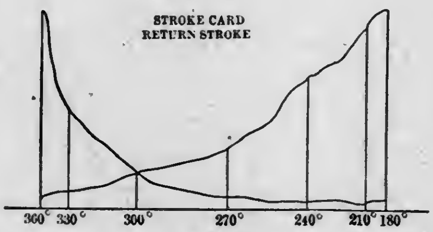


FIG. 8.

FIGS. 7 AND 8.—STROKE CARDS FOR THE INDICATOR CARD SHOWN IN FIG. 6.

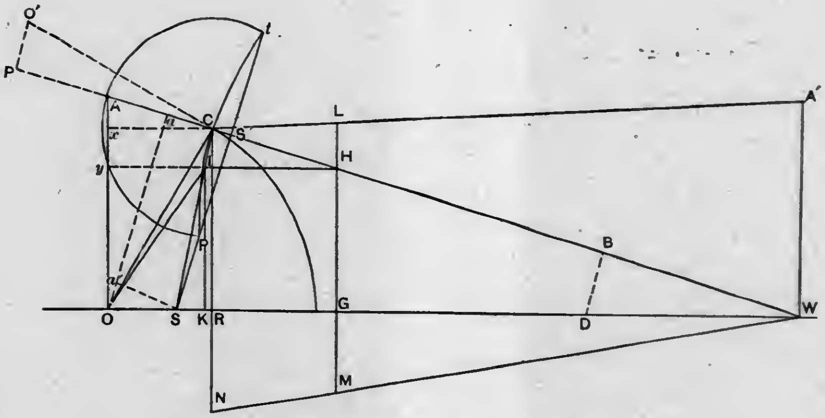


FIG. 5.—CONNECTING ROD THROW DIAGRAM.

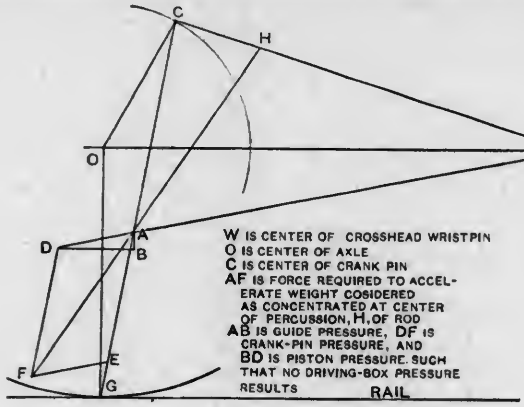
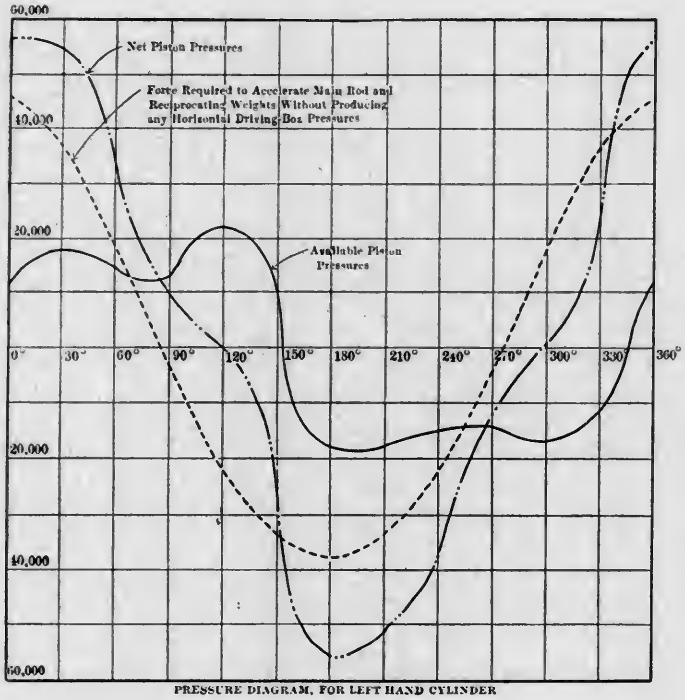
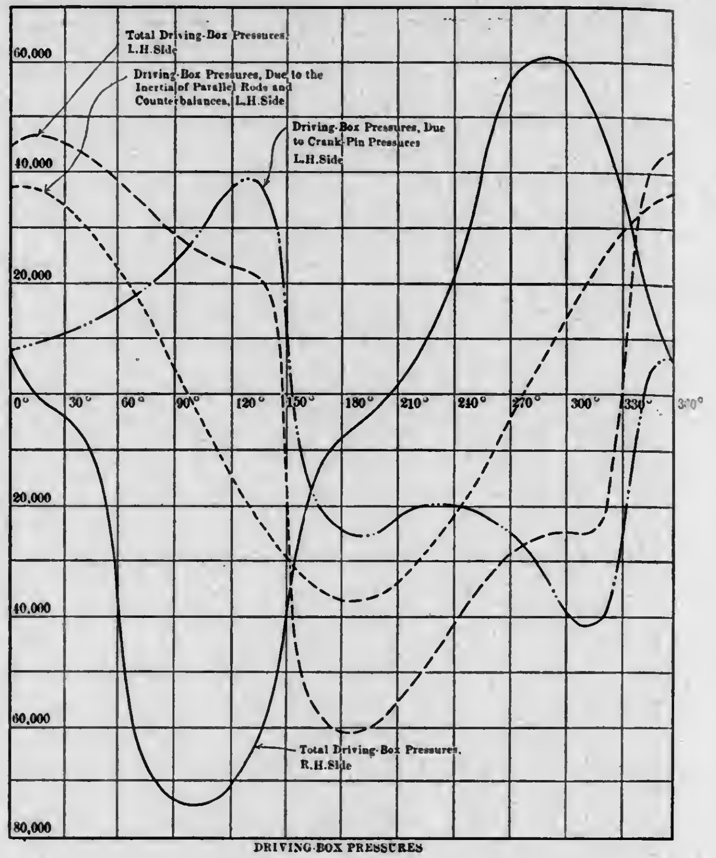


FIG. 9.



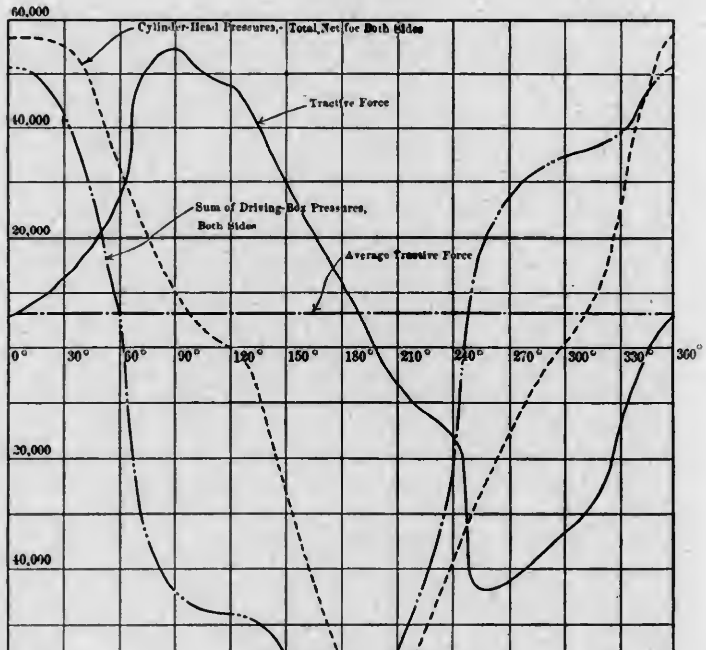
PRESSURE DIAGRAM, FOR LEFT HAND CYLINDER

FIG. 10.



DRIVING-BOX PRESSURES

FIG. 11.



TRACTIVE FORCE DIAGRAM

FIG. 12.

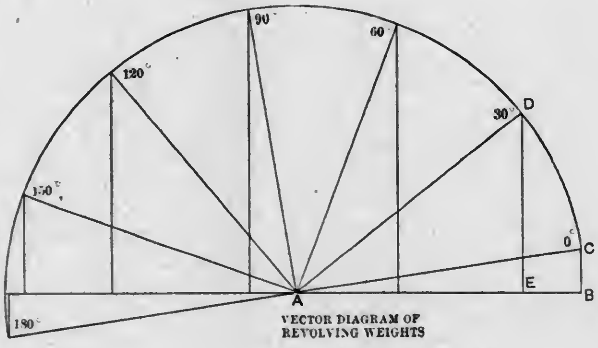


FIG. 13.

is considered as concentrated at the front bearing, so that it, the piston, piston-rod, and crosshead constitute the reciprocating weights, the sum of which, when multiplied by (OS) $\times \frac{v^2}{g}$ (Fig. 5) gives the force required for their acceleration.

To ascertain the forces required to accelerate the weight at the center of percussion, the diagram in Fig. 9 is made, the points O, C, H, and W being the same as in Fig. 5. OG is the radius of the main wheel, and G is its point of contact with the rail. In order that the action of the rod shall not produce pressure of the driving-boxes against the shoes or wedges, the direction of the force exerted by the crank-pin on its bearing must be in the direction CG. The direction of the resultant force acting on the mass at H must be HA, parallel to OI in Fig. 5. Therefore, the force at the crosshead-pin must act in the direction WA; if AF represents the mass at H multiplied by its acceleration, (OI) $\times v^2$ (Fig. 5), AD will be the corresponding force at the crosshead, BD being supplied by piston pressure and AB by guide pressure.

In Fig. 10 are plotted the net piston pressures in the left-hand cylinder and the forces required at the piston to accelerate the reciprocating weight as well as the weight at H, found as above described. There is also shown the difference between these two,

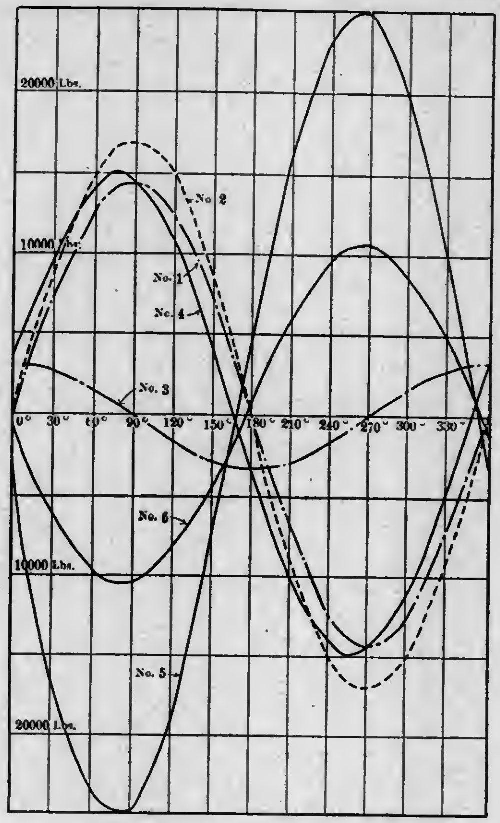


FIG. 14.—VARIATION IN VERTICAL RAIL PRESSURE, MAIN DRIVING WHEEL, LEFT SIDE OF ENGINE.

Curve No. 1. Due to reciprocating weights and main rod, left side.
Curve No. 2. Due to weight at crank pin equal to weight of back end of main rod.
Curve No. 3. Due to reciprocating weights and main rod, right side.
Curve No. 4. Sum of Nos. 1 and 3.
Curve No. 5. Due to parallel rods and counterbalances.
Curve No. 6. Sum of Nos. 4 and 5.

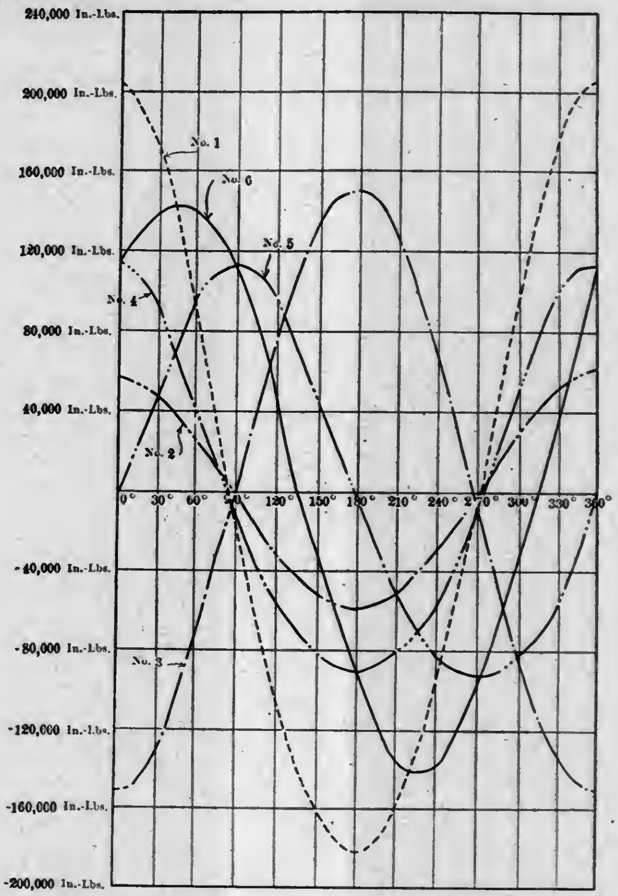


FIG. 15.—DIAGRAM OF TURNING MOMENTS DUE TO INERTIA OF REVOLVING AND RECIPROCATING PARTS AT A SPEED OF 60.5 MILES PER HOUR, BEGINNING AT FORWARD DEAD POINT, LEFT-HAND SIDE. POSITIVE MOVEMENTS TEND TO FORCE FRONT END OF THE ENGINE TO RIGHT.

Curve No.	Moment Due To:
1	Main rod and reciprocating weights, left side.
2	Parallel rods, left side.
3	Counterbalances, left side.
4	Sum of Nos. 1, 2 and 3, left side.
5	Corresponding to No. 4, right side.
6	Sum of Nos. 4 and 4.

which is the force available for transmission to the crank-pin for producing driving-box pressure. The force required for the acceleration of the weights is shown to constitute a considerable portion of the net piston pressure.

In Fig. 11 is plotted the driving-box pressure due to the available net piston pressure, obtained as in the case of the slow-speed diagram. There is also plotted the driving-box pressure due to the parallel rods and counterbalances. These may be found by multiplying the centrifugal forces by the cosine of the crank angle and by the leverage due to the frame spacing, and adding the various products. This, of course, can be done by computation or graphically. The same results can be obtained by means of the vector diagram shown in Fig. 13, which method is similar to that by which sine waves of alternating voltage or current strength are combined by the electrical engineer. AB is the centrifugal force at the side near the box, multiplied by its leverage, while BC is the centrifugal force on the opposite side multiplied by its leverage. AC is the resultant force, and AE and DE are its components when it has revolved through some angle, as 30°. There are also plotted in Fig. 11 the total driving-box pressures for each side.

In Fig. 12 are plotted the total cylinder-head pressures and the total driving-box pressures for both sides. The difference between these is the tractive force, the average of which agrees with that obtained by formula, using the mean effective pressure of the indicator card. *It should be noted that the average tractive force is very small compared with either the maximum or minimum tractive force or the total loads on the frames; that during a part of the revolution of the wheels there is a considerable negative tractive force, tending to retard the speed of the train; that the variation in tractive force is much greater than at slow speeds, producing the familiar fore-and-aft vibrations so noticeable on engines at high speed; but that the forces acting on the frames are much smaller at high speed than at low speed.*

If we wish to get the variation in vertical rail pressure, we return to Fig. 5, where $(IK) \times v^2 \times \frac{WH}{WC}$ multiplied by the leverage of the transverse wheel spacing and the overhang of the crank-pin, and by the mass concentrated at H, will give the load at the rail due to the throw of the main rod. If the engine is working steam, the available piston pressure will produce a crank-pin pressure which will have a vertical component to be added to the vertical throw of the main rod already obtained; if the engine is drifting, the inertia of the reciprocating parts will produce a crank-pin pressure to be similarly treated. Fig. 14 shows the variation in vertical rail pressure at the left-hand main wheel. It is often assumed that the weight required for perfect vertical balance is one to balance the static weight of the back end of the main rod. Curve No. 2 shows the variation in rail pressure due to such a counterbalance. It differs markedly from curve No. 1, which shows the actual variation, and the difference would be still more pronounced if the rod was shorter. The methods of obtaining the other curves of this figure are apparent from what has preceded. Curve No. 6 shows the vertical overbalance.

Fig. 15, derived in a similar way, shows the tendency of the engine to oscillate about a vertical axis. This is a diagram of moments, however, and the arms of the moments are the distances of the moving parts from the center of the engine. This diagram brings out the well-known fact that, though the engine is overbalanced vertically, it is underbalanced horizontally.

Modifications and a number of other applications of the diagrams will suggest themselves to those who desire to use

them. Following is the proof of the facts stated about Fig. 5 on page 378.

APPENDIX.

If we denote by v the angular velocity of the crank, $(OC) \times v$ will represent in magnitude the linear velocity of C, and $(OR) \times v$ and $(CR) \times v$ will be its vertical and horizontal components respectively. Draw CO^1 perpendicular to OC and equal to it in length. $(CO^1) \times v$ will represent the component of it acting along WC. WB is next made equal to CP, and BD is drawn perpendicular to WC. Then $(WD) \times v$ represents the velocity of W in magnitude and direction. From the similarity of triangles OaC and O^1PC, and AOa and BDW, it follows that $OA = WD$, and that $(OA) \times v$ represents the velocity of W in magnitude.

Since $(CR) \times v$ and $(RN) \times v$ represent the horizontal and vertical components of the velocity of C, and since $(WD) \times v, = (WA^1) \times v$, represents the horizontal velocity of W, the proportionality requires that $(GM) \times v$ and $(GL) \times v$ represent in magnitude the vertical and horizontal components respectively of any point H in the rod.

$(OC) \times v^2$ represents the acceleration of the crank pin, and $(Ca) \times v^2$ is its component along WC. Since $(OA) \times v$ is the velocity of W and $(OC) \times v$ that of C, both perpendicular to the actual directions of motion of these points, $(AC) \times v$ will be the velocity of C relatively to W. Therefore $\frac{(CA)^2 \times v^2}{(CW)}$ is the acceleration of C relatively to W, due to the oscillation of the rod about W. Now $CS^1 = \frac{(Cp)^2}{CW} = \frac{(CA)^2}{CW}$, therefore $(CS^1) \times v^2$ is the acceleration of C relatively to W. The total component of the accelerationn of W, in the direction WC is, therefore, $(Ca) \times v^2 + (CS^1) \times v^2 = (S^1a) \times v^2 = (Sa^1) \times v^2$. The actual acceleration of W in its actual direction is $(OS) \times v^2$. Since $(OC) \times v^2$, having components $(OR) \times v^2$ and $(CR) \times v^2$, represents the acceleration of C, and since $(OS) \times v^2$ similarly represents that of W, it follows from the proportionality that $(OI) \times v^2$ is the acceleration of any point in the rod as H, and $(OK) \times v^2$ and $(IK) \times v^2$ are its horizontal and vertical components respectively.

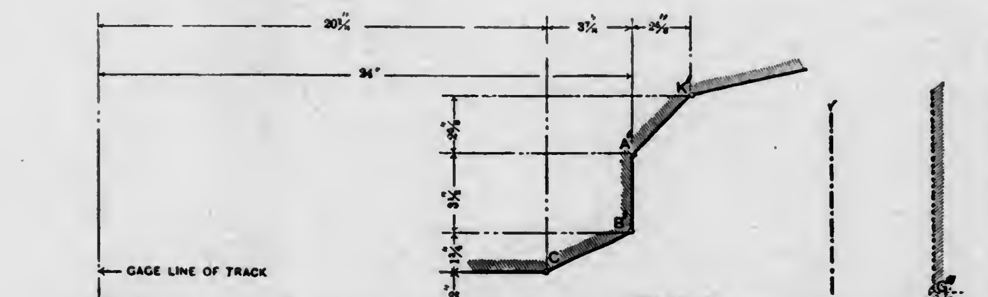
STANDARD LOCATION OF THIRD-RAILS.

At the last meeting of the American Railway Association the following resolutions were adopted:

"1. That the diagram showing lines of clearance be approved and made the standard of the American Railway Association; and that in the future construction of rolling stock and roadways these clearance lines be carefully adhered to by the members of the association.

"2. That in designs of new rolling equipment which is to be used in interchange, the clearance line K′, A′, B′, C′, including such horizontal and vertical variations which may in any reasonable probability occur in combination at one time, should not be exceeded. In determining this, the position of the equipment on a 20-degree curve should be considered, making allowance for the side throw of the bolster and the consequent effect on the location of such portions of the equipment that are attached to the car body. Variations in equipment should be allowed for as follows: Horizontal, 2½ inches in all; vertical, 4 inches in all.

"3. That in design of new bridges, trestles, tunnels and platforms, no part that is continuous for more than seven feet should come within the space indicated for third-rail structures, that is, A, B, C, D, E, F, G, H, I, J, K, and should preferably clear this line by at least one inch, as is shown by the line C″, D″, E″, F″, G″, but that structures which are not continuous for more than seven feet may be allowed to come to the line X Y."



CLEARANCE DIAGRAM FOR THIRD RAIL.

LONGITUDINAL vs. TRANSVERSE ERECTING SHOPS.

In speaking before the Canadian Railway Club, H. H. Vaughan had this to say of the transverse shop:

"I was quite a believer in the transverse shop when I went to the Lake Shore & Michigan Southern, but I am now prepared to endorse the longitudinal shop. The first objection I have to the double banked transverse shop is the inflexibility of it. Everything has to come in or out on either one or two tracks. I cannot help but feel that a recognition of the inflexibility of the double banked shop is shown by the plans in which a transfer table is used with a transverse shop.

"The transverse shop is a great deal misunderstood as regards floor space required. For instance, we will say that you have a pit section 60 feet wide. The fact is overlooked that in the machine shop there is a through track, as a rule about 15 ft. from the erecting shop, and the whole of the space between the repair shop and the track is taken up with wheels and storage, so that the transverse shop is generally about 80 feet instead of, as a rule about 65 feet, in the longitudinal shop; this takes a lot of space off the machine shop. I think if the longitudinal shop is laid out with the same floor space as the transverse shop that there is no appreciable difference in handling either engines or material, but I consider that in a longitudinal shop, transverse aisles leading to the machine shop should be arranged for about four or five engines apart. We did try to work that at Angus to a certain extent, but we were blocked by the arrangement of the machines, which had already been located in many cases. Had we been able to carry it out we would have had a most convenient shop for transferring material.

"There is another point and that is the effect of the type of shop on the lay-out of the machinery. All transverse shops have the same defect, the heavy tools are located along the track through the machine shop and block the movement to the back of the shop and the lighter machines, and the bench work has to be located under the gallery. In the longitudinal shop you can locate all the heavy tools close to the repair shop, leaving the space on the opposite side of the through track for the lighter tools, so that material can be handled to the heavy tools on one side and to the lighter tools on the other side of the machine shop track, and it is possible, as has been arranged at Angus, to place all the bench work out under the crane service keeping the lighter tools on which the work can generally be more easily watched under the gallery.

"It is stated that in a transverse shop it is easier to handle wheels, as a rule, than in a longitudinal shop. This is not true, however, of flues, boilers, and a variety of material, all of which can be handled through a longitudinal shop, and not have to be handled through the machine shop first. I feel there is a difficulty to make out any case for the superiority of the transverse shop, and if so, there is no reason for the additional expense it entails."

The directors of the Illinois Central Railroad, at a meeting in New York, September 16, authorized the appointment of a commission to fully investigate the matter of electrifying the Chicago terminal.

SECOND ANNUAL CONFERENCE OF THE APPRENTICE INSTRUCTORS, NEW YORK CENTRAL LINES.

The second annual conference* of the apprentice instructors of the New York Central Lines took place at Depew, N. Y., September 3. In addition to C. W. Cross, superintendent of apprentices, Henry Gardner, his assistant, and the instructors whose names are shown on the accompanying table, the following guests were present: C. H. Hogan, division superintendent of motive power; F. M. Gilbert, mechanical engineer; F. W. Thomas, supervisor of apprentices, Santa Fé., and Henry Maxwell, educational instructor of apprentices in the locomotive department of the Canadian Pacific Railway Company at Angus Works. At the opening of the conference letters were read from J. F. Deems, L. H. Turner and G. M. Basford. Following are extracts from these:

Drawing Instructor.	Shop Instructor	Shop.
A. W. Martin	W. J. Greilich	Beech Grove, Ind.
R. M. Brown	H. J. Cooley	Collinwood, O.
G. Kuch, Sr.	G. Kuch, Jr.	Depew, N. Y.
F. Deyot, Jr.	L. T. Johnson	East Buffalo, N. Y.
C. A. Towsley	M. T. Nichols	Elkhart, Ind.
C. P. Wilkinson	C. T. Phelan	Jackson, Mich.
V. J. Burry	J. R. Radcliffe	McKees Rocks, Pa.
H. S. Rauch	F. Hanley	Oswego, N. Y.
H. R. Martinson	H. R. Martinson	St. Thomas, Ont.
A. L. Devine	F. Nelson	West Albany, N. Y.

Mr. Deems.—"There is no more important problem now confronting the railroads, and especially the mechanical department of railroads, than the future relationship between the employees and the companies. You are engaged in the work of the systematic training of apprentices in the theory and the practice of the trades, to raise the standard of mechanics in the shops, for the mutual benefit of the company and the employees.

"The value of this plan of training apprentices may not be apparent in the first year of apprenticeship, but later it is shown there is a very decided benefit to the apprentice himself, as well as the company, and in time this must be reflected in the community.

"Those of us who have served an apprenticeship under the old régime know the difficulties we had to overcome in learning the trade. It is believed the apprentices on our lines fully appreciate the privileges afforded, as is evidenced by the eagerness and ambition displayed on their part, which is commendable to both the instructors and the apprentices.

"The relation of both the drawing instructor and the shop instructor to the local organization is especially important, he should make every effort to impress on all concerned that his efforts are co-operative with the object of increasing the output and efficiency of the shop in general."

Mr. Turner.—"I cannot refrain from saying to you that I am very much impressed with the work that is being accomplished, which is sure to result in building up a much better class of mechanics on the Lines; also a better class of men to draw from when men are to be selected to take supervisory positions. You are to be complimented on the splendid work you are doing."

Mr. Basford.—"It would be a great pleasure to me to meet the men who are working out the details of a plan which seems to be one of the most important movements of the time in the most important problem of the time—transportation.

"For many years I have dreamed of seeing apprenticeship worked out practically on a large scale, as you are working it out, and that the dream has come true is almost too good to believe.

"What does it matter if the work involves a good deal of drudgery? Is there any work worth while which does not involve it? I think that everything should be said and done to encourage those who are carrying the burden of this effort. The most encouraging thing that I can think of to say is that there is nothing in any industrial or transportation organization which begins to approach in importance and in the possibilities of far-reaching results, this preparation of recruits who are to be the men of the future. I think you should bear in mind the fact that the New York Central Lines were first in the field in a broad effort of this sort. Remember that other railroads are watching and following you and that it will be necessary to be alert and active in order to maintain the lead which you now hold. The best of success to you and to all who are helping you in this development which has been so ably organized by Mr. Deems."

C. H. Hogan, Div. Supt. M. P., then spoke in part as follows: "We see here at Depew Shops the results of the labor of the apprenticeship department. The company has incurred the expense of installing the school and providing for the practical training of apprentices—to educate them to become skilled mechanics. At first the apprentice may not think much of the training he is being given, but at the end of the fourth year he will say that he would not have gained the theoretical knowledge and thorough practical training if it were not for your efforts, and he will show his gratitude for the opportunity given him. The other day a professor from one of the high schools of Buffalo visited our school and shop and expressed his surprise that the railroad company took so much interest in their apprentices and stated he would like to have all his instructors visit our school."

Mr. Cross' Address.—Mr. Cross then addressed the conference. He directed attention to the rapid extension and progress of modern apprenticeship methods on railroads throughout the country and reviewed the work of the apprenticeship committee at the last meeting of the Master Mechanics' Association. He closed with the following remarks:

"The testimony of all subordinate officers and others who are in a position to know, is to the effect that the company is deriving benefits from the training of apprentices and that the apprentice work is on a conservative and substantial basis. The shop instructor increases the efficiency and consequently the output of the apprentices by his instructions, and the drawing instructors increase their knowledge and efficiency by the instruction given in drawing and mathematics.

"The New York Central Lines plan of apprenticeship is intended to provide for recruiting the service by combining the shop instruction with the theoretical training. We feel that the work has now passed the experimental stage and has become a regular part of the work of the railroad. The value of this plan of training is that it enables the company to reap an immediate, as well as an ultimate benefit from the work done by apprentices, due to the special training they receive both in the school room and the shop. The aim is to have a light crop over a large area, rather than a phenomenal growth of a few plants. The progress made during the year indicates a substantial growth of the ideas of apprenticeship for recruiting the service. The apprentices everywhere acknowledge by their earnestness their gratitude for the opportunity offered for self-improvement. The interest displayed by the apprentices so far is very gratifying, and is increasing in proportion as the facilities for experimental work are increased and the plan of instruction is extended."

*An abstract of the proceedings of the first annual conference will be found in the November, 1907, issue of this journal.

Apparent Benefits From Improved Apprenticeship Methods.

By Henry Gardner.

General Benefits to Shops.

Investigation shows that the apprentices in all departments are doing better work than formerly—are in fact doing certain classes of high-grade work, which under the old system it was not thought wise to entrust to them.

Discipline in the shop is better. Foremen are relieved of the care of the boys and can give more attention to their other duties. The shop instructor takes charge of the apprentices and contributes materially to increasing the output by his constant teaching and inspection. The best grade of work is given boys in all departments. It is a common occurrence in all shops to excuse a boy from the class room in order to run a machine left idle by an absent workman, thus keeping up the output of the machine.

The tone of the shop is improved in several cases by high school boys as apprentices. This is the natural result of the educational advantages offered by modern apprenticeship. There is a steady gain in the boys' ability to read blue prints and drawings. This faculty is strongly marked during the third and fourth years. Boys can read ordinary shop prints at the end of the first year.

Debating clubs give the boys an opportunity to write and talk on mechanical subjects. Speaking in public makes and develops initiative. The ability to do this is traceable to the class-room instruction. Club socials and picnics bind boys to their fellow-workmen and build up valuable friendships. The boys learn to understand and respect their superiors, but not to fear them. The baseball club, if properly managed, may be classed as a benefit. Boys are broadened by their visits to other shops. The unity of the club teaches that success is due to team work.

General Benefits to the Drafting Room.

Boys are used in the drafting room both before and after graduation. Before graduation those best fitted for the work spend three months making blue prints, drawings and tracings. After graduation, boys especially adapted are used to advantage as regular draftsmen. When rushed the head draftsman takes drawings to the apprentice class room to be worked up or traced. Apprentices assist the drafting room in making numerous tests, such as indicating engines, dynamometer car tests, coal tests, etc.

During the past year a total of 1,344 drawings and tracings have been made for the company's drawing room files by apprentices. Part of these were made in the class room and others by apprentices especially detailed for drawing room duty.

Special Instances of Good Work in the Shop.

(These are a few of many jobs which indicate the class of work which is open to the apprentices, as well as the fact that they are taking advantage of their opportunities.)

West Albany Shops.—A first year apprentice, with only two weeks experience, bored twelve eccentrics in thirteen hours, and five eccentric straps in seven and a half hours.

A second year apprentice, with helper, set the valves on an engine in seven hours. Set valves on two other engines in good time.

A second year apprentice, with helper, lined up two sets of guides and coupled up pistons, all in six hours. Boy had three months' experience in this work.

A third year apprentice in charge of the rod job, repaired thirty-two main rods, ten pairs front end brasses, and eighteen pairs back end brasses. He also made two sets of front end brasses. All of this work was done in three weeks.

MEMBERS PRESENT AT APPRENTICE INSTRUCTORS' CONFERENCE.

Top row, reading from left: G. Kuch, Sr., H. J. Cooley, F. Hanley, H. S. Rauch, A. W. Martin, M. T. Nichols, and H. Maxwell (Can. Pac. Ry.). Middle row, reading from left: G. Kuch, Jr., F. Nelson, L. T. Johnson, F. W. Thomas (Santa Fe), C. W. Cross, Henry Gardner, C. P. Wilkinson, C. A. Towsley, and H. R. Martinson. Bottom row, reading from left: R. M. Brown, W. J. Greilich, F. Deyot, Jr., C. T. Phelan, A. L. Devine, V. J. Burry and J. R. Radcliffe.

Collinwood Shops.—A first year apprentice applied two boiler checks to a new boiler, laid out and tapped holes for studs and ground the seats, completing the job in twelve hours.

Apprentice boys ran a 42 in. truck wheel lathe, turning an average of five pairs of tires per day. The average done by the regular piece worker on this job was six pairs per day.

The third year foundry apprentices are doing regular moulding work at the bench.

A third year boy patched a cylinder, assisted by a helper.

A third year apprentice and helper took charge of the truck job temporarily. Work was satisfactory.

Elkhart Shops.—A third year apprentice laid out a drop pit jack for engine house from blue print.

Oswego Shops.—Apprentice with three months' experience, with helper, ran the link job successfully. The regular man was temporarily absent.

A statement of eleven boys working piece work shows an average increase in rate of pay for June over May, 1908, of 15 per cent. This increase is mainly due to the appointment of a shop instructor.

McKees Rocks Shops.—Two fourth year apprentices had full charge of a pit with an engine in for general repairs. The boys ordered all parts, made sketches for new bolts, lined up the guides, laid off the shoes and wedges, wheeled and trammed the engine and set the valves. The foreman advised them as is customary in ordinary cases.

A fourth year apprentice took complete charge of erecting a new engine, including the following jobs: leveling and squaring the frames, scribing and chipping the saddle, laying off the shoes and wedges and wheeling and tramming the engine. He did not set the valves. The foreman advised, as customary.

SPECIFIC BENEFITS TO THE DRAFTING ROOM.

West Albany.—A graduate machinist apprentice went to the New York office as a draftsman. Prior to that time he attended shop evening classes for two months, and public school evening classes for six months, winning a medal for the best drawing in the public school evening classes.

A fourth year apprentice redesigned a grease molding machine, including one assembly and ten detail drawings. He also designed a set of dies for bending fire rake handles. These dies are now in use.

Eight boys, machinist apprentices, have assisted on dynamometer car tests.

Collinwood.—A first year machinist apprentice is drawing forging machine dies for office record.

A second year machinist apprentice made a complete list of all regular tools in the shop, collecting prices and putting a value on each.

Two second year machinist apprentices were on a coal test for four months, checking and weighing amount of coal used for locomotives.

A third year machinist apprentice conducted a test of a Haushalter speed recorder, riding on passenger engines between Chicago and Buffalo.

A third year machinist apprentice is making a complete set of drawings of boiler hand tools for office use.

Elkhart.—Three machinist apprentices, fourth, second and first year, are running a coal test.

A fourth year machinist apprentice spent six months as a draftsman in the Cleveland office.

Oswego.—A third year machinist apprentice made the drawings for a bolt shear, while in the drawing room. He worked up the details from notes and sketches. The shear was made from these drawings.

McKees Rocks.—Two fourth and one second year apprentices have for the past six months been sketching and drawing bulldozer dies for the mechanical engineer's office. This work was done during school hours.

A third year machinist apprentice, with the instructor's assistance, has designed a complete link and reversing gear for the small stationary engine in the class room. All parts will be made in the shop from these drawings.

A graduate apprentice has been enrolled as a regular draftsman in the mechanical engineer's office.

Two apprentices will be chosen to assist the drawing room force in making some dynamometer car tests.

Apprentice Clubs and Baseball Teams.

REPORTS OF PROGRESS.

Depew (G. Kuch, Sr.)—An apprentice debating club was organized last December. Discussions are carried on during the noon hour. The apprentices are divided into three classes, machinist, boiler maker and blacksmith, each taking up subjects in their own line, but open to all for debate. The assistant shop draftsman is chairman of the club, the assistant chairman and recording secretary being apprentices. The meetings were a complete success and were largely attended not only by the apprentices but by the shop foremen and journeymen. From the organization of the club the foremen have been regular attendants and have willingly instructed the apprentices whenever called upon. They also wish to be informed of the names of the apprentices who miss these meetings.

Following is a list of the subjects which were discussed. How does water enter the boiler with the same amount of pressure on the boiler check as on the injector? What are the advantages and disadvantages of the Stephenson and Walschaert valve gear? Functions of a slide valve and a piston valve. Different kinds of welds. Method of keeping fires in a forge to obtain the best results. Why are 2-in. flues used in a locomotive boiler instead of 3 or 3½ in.? Different types of locomotive boilers. How many different kinds of seams are there in a locomotive boiler? How to find the pressure on a staybolt.

The club adjourned April 15th because of warm weather and in order to organize a baseball team. Funds for securing uniforms and a complete baseball equipment were obtained from the proceeds of a ball which was conducted entirely by apprentices. The baseball team, composed of apprentices, has played six games.

Elkhart. (C. A. Towsley).—The apprentice club at this point is under the necessity of renting a room; because of this the dues are higher and the membership has fallen off somewhat. It is expected, however, that with longer working hours and more pay it will be considerably increased. The proceeds of an ice cream social has helped the club to better its financial condition.

A number of talks have been given by various shop foremen, including the following subjects: Drilling and drilling machines. Stephenson valve motion. Planers. Early history of the locomotive. Laying out work. Shoes and wedges. Vital points of a locomotive. Pattern making. Clamps and clamping.

The average attendance at the meetings was 21 apprentices. A question box helps to keep up the interest. The questions are read at the meeting and if none of the apprentices are able to answer them they are assigned to be looked up and presented at the next meeting. In August the apprentices held an outing at Bawbeese Lake. During the early part of the season the company cleared a space for a baseball ground. Seven regular games were played.

Oswego. (H. S. Rauch).—An apprentice debating club was organized October, 1907, with a membership of 14. It has since grown to include 19 out of the 20 apprentices. Fifteen meetings have been held; until May they were held at intervals of two weeks; since that time and continuing until fall they will be held at intervals of four weeks. The club is organized somewhat along the lines of a fraternal organization, having an initiation ceremony and the following named officers: Master mechanic, general foreman, chief clerk, treasurer and watchman.

The following topics have been considered: Is a locomotive composed of one or two engines? Why do passenger engines have larger wheels than freight engines? Why are shoes and wedges used? Why not solid jaws? When the main crank pin of a locomotive on the right side is on the lower quarter, in what position is the crank pin on the left side? Why are cylinders counter-bored? When laying out counter-bores in a cylinder how do you find the distance between them? How do you find the stroke of an engine? Screws and screw cutting. Illustrating the difference between the Whitworth, or English, standard and the United States standard screw. Square threads and how to grind the tool and set the lathe gears to cut them. Pressure plates—why are they used and how to find their height. Eccentric ring and its use. Care of locomotive boilers. The injector, its use and construction. Laying out shoes and wedges. Lining up guides. How to determine whether or not the driving axles are at right angles with the cylinders. Metallic packing; its use and construction.

A description of the McLaughlin joint was written and illustrated by a first year apprentice and a paper was prepared on "Modern Boiler Construction" by a boiler maker apprentice. Papers were also read on "How to Lay Out and Cut Gears" and "The Proper Method of Admitting Feed Water." An illustrated lecture was given on the Florida East Coast Railway and one of the apprentices gave an extended talk on valve setting, which was continued during ten meetings, the following sub-divisions being considered: Admission, cut-off, expansion, exhaust, compression, lead, inside and outside lap, marking off striking points, etc. This talk was illustrated with lantern slides. The apprentice who gave it made the drawings and these were photographed and made into slides.

At the regular club meetings business is first attended to. This sometimes includes the appointment of a committee to call on a sick apprentice. After this some sort of an entertainment is provided, which may consist of reading magazine articles, recitations or singing. Baseball or other sports, in which the boys are interested, are talked over at the proper time. The projection lantern has been used in connection with almost every meeting. The average attendance at club meetings has been 10.5. The baseball team has played two games with the Depew apprentices, and six games with outside teams.

Apprentice Clubs.

BENEFITS, DANGERS, SUGGESTIONS.

H. S. Rauch.—The benefits to be derived from a social, fraternal and educational organization combined are manifold. In the first place a spirit of fraternal feeling is instilled among the apprentices and a chance is given them to state their views on topics that are of common interest. They have an opportunity to listen to the experience of other young men on matters pertaining to their calling: in fact, the club room of our apprentice boys, as it has been handled at Oswego, in a measure takes the place of the college lecture room. Facts which are of vital interest to all young men starting out on a railroad career can be

Apparent Benefits From Improved Apprenticeship Methods.

By Henry Gardner.

General Benefits to Shops.

Investigation shows that the apprentices in all departments are doing better work than formerly—are in fact doing certain classes of high-grade work, which under the old system it was not thought wise to entrust to them.

Discipline in the shop is better. Foremen are relieved of the care of the boys and can give more attention to their other duties. The shop instructor takes charge of the apprentices and contributes materially to increasing the output by his constant teaching and inspection. The best grade of work is given boys in all departments. It is a common occurrence in all shops to excuse a boy from the class room in order to run a machine left idle by an absent workman, thus keeping up the output of the machine.

The tone of the shop is improved in several cases by high school boys as apprentices. This is the natural result of the educational advantages offered by modern apprenticeship. There is a steady gain in the boys' ability to read blue prints and drawings. This faculty is strongly marked during the third and fourth years. Boys can read ordinary shop prints at the end of the first year.

Debating clubs give the boys an opportunity to write and talk on mechanical subjects. Speaking in public makes and develops initiative. The ability to do this is traceable to the class room instruction. Club socials and picnics bind boys to their fellow-workmen and build up valuable friendships. The boys learn to understand and respect their superiors, but not to fear them. The baseball club, if properly managed, may be classed as a benefit. Boys are broadened by their visits to other shops. The unity of the club teaches that success is due to team work.

General Benefits to the Drafting Room.

Boys are used in the drafting room both before and after graduation. Before graduation those best fitted for the work spend three months making blue prints, drawings and tracings. After graduation, boys especially adapted are used to advantage as regular draftsmen. When rushed the head draftsman takes drawings to the apprentice class room to be worked up or traced. Apprentices assist the drafting room in making numerous tests, such as indicating engines, dynamometer car tests, coal tests, etc.

During the past year a total of 1,344 drawings and tracings have been made for the company's drawing room files by apprentices. Part of these were made in the class room and others by apprentices especially detailed for drawing room duty.

Special Instances of Good Work in the Shop.

(These are a few of many jobs which indicate the class of work which is open to the apprentices, as well as the fact that they are taking advantage of their opportunities.)

West Albany Shops.—A first year apprentice, with only two weeks experience, bored twelve eccentrics in thirteen hours, and five eccentric straps in seven and a half hours.

A second year apprentice, with helper, set the valves on an engine in seven hours. Set valves on two other engines in good time.

A second year apprentice, with helper, lined up two sets of guides and coupled up pistons, all in six hours. Boy had three months' experience in this work.

A third year apprentice in charge of the rod job, repaired thirty-two main rods, ten pairs front end brasses, and eighteen pairs back end brasses. He also made two sets of front end brasses. All of this work was done in three weeks.

Collinwood Shops.—A first year apprentice applied two boiler checks to a new boiler, laid out and tapped holes for studs and ground the seats, completing the job in twelve hours.

Apprentice boys ran a 12 in. truck wheel lathe, turning an average of five pairs of tires per day. The average done by the regular piece worker on this job was six pairs per day.

The third year foundry apprentices are doing regular moulding work at the bench.

A third year boy patched a cylinder, assisted by a helper.

A third year apprentice and helper took charge of the truck job temporarily. Work was satisfactory.

Elkhart Shops.—A third year apprentice laid out a drop pit jack for engine house from blue print.

Oswego Shops.—Apprentice with three months' experience, with helper, ran the link job successfully. The regular man was temporarily absent.

A statement of eleven boys working piece work shows an average increase in rate of pay for June over May, 1908, of 15 per cent. This increase is mainly due to the appointment of a shop instructor.

McKees Rocks Shops.—Two fourth year apprentices had full charge of a pit with an engine in for general repairs. The boys ordered all parts, made sketches for new bolts, lined up the guides, laid off the shoes and wedges, wheeled and trammed the engine and set the valves. The foreman advised them as is customary in ordinary cases.

A fourth year apprentice took complete charge of erecting a new engine, including the following jobs: leveling and squaring the frames, scribing and chipping the saddle, laying off the shoes and wedges and wheeling and tramming the engine. He did not set the valves. The foreman advised, as customary.

MEMBERS PRESENT AT APPRENTICE INSTRUCTORS' CONFERENCE.

Top row, reading from left: G. Kuch, Sr., H. J. Cooley, F. Hanley, H. S. Rauch, A. W. Martin, M. T. Nichols, and H. Maxwell (Can. Pac. Ry.). Middle row, reading from left: G. Kuch, Jr., F. Nelson, L. T. Johnson, F. W. Thomas (Santa Fe), C. W. Cross, Henry Gardner, C. P. Wilkinson, C. A. Towsley, and H. R. Martinson. Bottom row, reading from left: R. M. Brown, W. J. Greilich, F. Deyot, Jr., C. T. Phelan, A. L. Devine, V. J. Burry and J. R. Radcliffe.

Specific Benefits to the Drafting Room.

West Albany.—A graduate machinist apprentice went to the New York office as a draftsman. Prior to that time he attended shop evening classes for two months, and public school evening classes for six months, winning a medal for the best drawing in the public school evening classes.

A fourth year apprentice redesigned a grease molding machine, including one assembly and ten detail drawings. He also designed a set of dies for bending fire rake handles. These dies are now in use.

Eight boys, machinist apprentices, have assisted on dynamometer car tests.

Collinwood.—A first year machinist apprentice is drawing forging machine dies for office record.

A second year machinist apprentice made a complete list of all regular tools in the shop, collecting prices and putting a value on each.

Two second year machinist apprentices were on a coal test for four months, checking and weighing amount of coal used for locomotives.

A third year machinist apprentice conducted a test of a Haushalter speed recorder, riding on passenger engines between Chicago and Buffalo.

A third year machinist apprentice is making a complete set of drawings of boiler hand tools for office use.

Elkhart.—Three machinist apprentices, fourth, second and first year, are running a coal test.

A fourth year machinist apprentice spent six months as a draftsman in the Cleveland office.

Oswego.—A third year machinist apprentice made the drawings for a bolt shear, while in the drawing room. He worked up the details from notes and sketches. The shear was made from these drawings.

McKees Rocks. Two fourth and one second year apprentices have for the past six months been sketching and drawing bulldozer dies for the mechanical engineer's office. This work was done during school hours.

A third year machinist apprentice, with the instructor's assistance, has designed a complete link and reversing gear for the small stationary engine in the class room. All parts will be made in the shop from these drawings.

A graduate apprentice has been enrolled as a regular draftsman in the mechanical engineer's office.

Two apprentices will be chosen to assist the drawing room force in making some dynamometer car tests.

Apprentice Clubs and Baseball Teams.

Reports of Progress.

Depew (G. Kuch, Sr.)—An apprentice debating club was organized last December. Discussions are carried on during the noon hour. The apprentices are divided into three classes, machinist, boiler maker and blacksmith, each taking up subjects in their own line, but open to all for debate. The assistant shop draftsman is chairman of the club, the assistant chairman and recording secretary being apprentices. The meetings were a complete success and were largely attended not only by the apprentices but by the shop foremen and journeymen. From the organization of the club the foremen have been regular attendants and have willingly instructed the apprentices whenever called upon. They also wish to be informed of the names of the apprentices who miss these meetings.

Following is a list of the subjects which were discussed. How does water enter the boiler with the same amount of pressure on the boiler check as on the injector? What are the advantages and disadvantages of the Stephenson and Walschaert valve gear? Functions of a slide valve and a piston valve. Different kinds of welds. Method of keeping fires in a forge to obtain the best results. Why are 2 in. flues used in a locomotive boiler instead of 3 or 3½ in.? Different types of locomotive boilers. How many different kinds of seams are there in a locomotive boiler? How to find the pressure on a staybolt.

The club adjourned April 15th because of warm weather and in order to organize a baseball team. Funds for securing uniforms and a complete baseball equipment were obtained from the proceeds of a ball which was conducted entirely by apprentices. The baseball team, composed of apprentices, has played six games.

Elkhart. (C. A. Towsley).—The apprentice club at this point is under the necessity of renting a room; because of this the dues are higher and the membership has fallen off somewhat. It is expected, however, that with longer working hours and more pay it will be considerably increased. The proceeds of an ice cream social has helped the club to better its financial condition.

A number of talks have been given by various shop foremen, including the following subjects: Drilling and drilling machines. Stephenson valve motion. Planers. Early history of the locomotive. Laying out work. Shoes and wedges. Vital points of a locomotive. Pattern making. Clamps and clamping.

The average attendance at the meetings was 21 apprentices. A question box helps to keep up the interest. The questions are read at the meeting and if none of the apprentices are able to answer them they are assigned to be looked up and presented at the next meeting. In August the apprentices held an outing at Bawbeese Lake. During the early part of the season the company cleared a space for a baseball ground. Seven regular games were played.

Oswego. (H. S. Rauch).—An apprentice debating club was organized October, 1907, with a membership of 14. It has since grown to include 19 out of the 20 apprentices. Fifteen meetings have been held; until May they were held at intervals of two weeks; since that time and continuing until fall they will be held at intervals of four weeks. The club is organized somewhat along the lines of a fraternal organization, having an initiation ceremony and the following named officers: Master mechanic, general foreman, chief clerk, treasurer and watchman.

The following topics have been considered: Is a locomotive composed of one or two engines? Why do passenger engines have larger wheels than freight engines? Why are shoes and wedges used? Why not solid jaws? When the main crank pin of a locomotive on the right side is on the lower quarter, in what position is the crank pin on the left side? Why are cylinders counter-bored? When laying out counter-bores in a cylinder how do you find the distance between them? How do you find the stroke of an engine? Screws and screw cutting. Illustrating the difference between the Whitworth, or English, standard and the United States standard screw. Square threads and how to grind the tool and set the lathe gears to cut them. Pressure plates—why are they used and how to find their height. Eccentric ring and its use. Care of locomotive boilers. The injector, its use and construction. Laying out shoes and wedges. Lining up guides. How to determine whether or not the driving axles are at right angles with the cylinders. Metallic packing; its use and construction.

A description of the McLaughlin joint was written and illustrated by a first year apprentice and a paper was prepared on "Modern Boiler Construction" by a boiler maker apprentice. Papers were also read on "How to Lay Out and Cut Gears" and "The Proper Method of Admitting Feed Water." An illustrated lecture was given on the Florida East Coast Railway and one of the apprentices gave an extended talk on valve setting, which was continued during ten meetings, the following sub-divisions being considered: Admission, cut-off, expansion, exhaust, compression, lead, inside and outside lap, marking off striking points, etc. This talk was illustrated with lantern slides. The apprentice who gave it made the drawings and these were photographed and made into slides.

At the regular club meetings business is first attended to. This sometimes includes the appointment of a committee to call on a sick apprentice. After this some sort of an entertainment is provided, which may consist of reading magazine articles, recitations or singing. Baseball or other sports, in which the boys are interested, are talked over at the proper time. The projection lantern has been used in connection with almost every meeting. The average attendance at club meetings has been 10.5. The baseball team has played two games with the Depew apprentices, and six games with outside teams.

Apprentice Clubs.

Benefits, Dangers, Suggestions.

H. S. Rauch.—The benefits to be derived from a social, fraternal and educational organization combined are manifold. In the first place a spirit of fraternal feeling is instilled among the apprentices and a chance is given them to state their views on topics that are of common interest. They have an opportunity to listen to the experience of other young men on matters pertaining to their calling; in fact, the club room of our apprentice boys, as it has been handled at Oswego, in a measure takes the place of the college lecture room. Facts which are of vital interest to all young men starting out on a railroad career can be

brought out and explained. Since the organization of the club the boys have written their own papers and given their own talks with no assistance except from the instructor. In doing this it has been necessary for them to study the subject upon which they were to talk. Every opportunity was given them to read up on these topics and information was thereby gained, which they would never have acquired had they not prepared the article for the club.

Another feature of the apprentice club is that there is always a quantity of the latest mechanical literature at hand, which brings them into close contact with the railroad world. The boys learn to feel that they are a part of the great combination, instead of only paid employees, and will often be heard to speak of the railroad with which they are connected as "Our Company," or "Our Road," showing that they have a natural pride in the success of the company. This loyalty is worth more in dollars and cents to the company than is perhaps apparent on the surface. These clubs give the apprentice boy a chance to become acquainted with his superior officers. He learns to know them as they are, and not to look upon them as holding an exalted position, and put there for the express purpose of grinding all the work out of them that he possibly can.

During the past winter Mr. Bradeen, the division superintendent of motive power, was a regular attendant at the club meetings, taking part in the debates. This created a friendly feeling among all concerned, and made us as one big family, each working for the interest of the other and all for the interest of the company.

The dangers from such a club are very small, if properly managed. It is the instructor's duty to attend all meetings of the club when possible, and while I believe that the whole control of the club should be in the hands of the apprentices, and officered by their own men, yet it is sometimes well to exercise a restraining influence over the management. If the instructor has the confidence and good-will of the boys they will ask his advice on all matters pertaining to the club affairs. There might be some danger in a club baseball team becoming a nuisance to the company if the thing is overdone, but with proper care and good judgment on the part of those in charge this can be controled. The boys are benefited in their visits to other shops to play ball, by becoming acquainted with other apprentices and foremen. The ball team illustrates that nothing can succeed without organization and system.

The ways and means of making the club more successful will in a measure have to work themselves out. I do not believe any set rules can govern all clubs, but I do believe that apprentice clubs should be in closer touch with each other than they have been in the past. Anything of special interest in one club should be communicated to the secretaries of other clubs. This will have a tendency to create rivalry, and no good healthy American boy likes to be beaten. Our plan as outlined for the winter is as follows: We expect to have quarters in a company building in the central part of the city; one room is to be fitted up as a reading room, one as a gymnasium and a third as the meeting room. We expect to follow the same lines as last year using our lantern for illustration and entertainments. The boys will write papers on topics assigned to them at the meeting preceding the one at which they are to be read, and as our meetings are two weeks apart there is ample time for preparation. We count on holding a few dancing parties to replenish our treasury, which will enable us, with careful management, to meet each situation as it arises.

R. M. Brown.—I believe the greatest benefit from an apprentice club is the experience gained by the boys in holding the different offices and also in getting accustomed to the way meetings of this kind are conducted. The benefits of the club to the apprentice also vary according to the distance he has to travel to reach the club room. In our club about one-half of the regular attendance live in Collinwood, while about four-fifths of the membership live in Cleveland. Many of the boys, after working all day, do not feel like riding eight or ten miles to attend an ordinary club meeting; in fact, many of them do not have the car fare.

The dangers of the organization are comparatively small, although careful watch must be kept to prevent gambling and cigarette smoking and to keep swearing at a minimum. The success of the apprentice club in a place like Collinwood can only be had by having the lowest possible dues, 25 cents per month being too much for some, and by having something especially interesting as often as possible. This we have found to result in lots of hard work on the part of a few.

Drawing Courses.

Should They Be Lengthened for Slower Boys and Should Brighter Boys Be Allowed to Omit Exercises?

C. A. Towsley.—The boy who is naturally bright and quick to grasp ideas and who possesses natural ability for drawing or sketching, will begin with the first sheet and continue to draw each succeeding sheet without requiring very much attention from the instructor. The various sheets lead up so gradually to the point where the boy is required to do some sketching, that practically no difficulty is encountered. For this class of boy I would suggest that a portion of the easier plates which appear occasionally throughout the course, be omitted. He may then more rapidly approach that portion of the course where sketching from machine and locomotive parts is necessary before making the drawing. The work requiring sketches more nearly approaches the work of the shop draftsman and should be given a prominent place in the course. It is especially valuable for those who give evidence of possessing natural ability, or who may be working with the idea of fitting for a draftsman's position.

The slower apprentices, those who are not of a mechanical turn of mind, or who have little natural ability, are up against a proposition when given the first drawing sheet, and require constant watching by the instructor or assistant. These boys generally make poor lines, letters and figures, and are obliged to erase frequently to rectify mistakes. Each succeeding lesson shows little improvement over the first, and when that portion of the course is reached where the boy is to take up sketching and advanced work, he is not fitted for it. In order to bring him up to this point successfully more lessons should be added to the course, so that he can be kept at the work until better qualified. While this arrangement is recommended it would be a difficult matter to decide just what portion should be omitted and what should be added to suit the variety of cases that may develop. My opinion is that the instructor should deal with each case as may best suit the individual.

G. Kuch, Sr.—I think that it would not be a good plan to lengthen the time in the drawing courses for slow apprentices, as this would have a tendency to make them slower. A slow boy usually requires more attention than a rapid one, and therefore he should be followed up constantly in order to teach him to work more quickly. If this is not done I find in my experience that slow boys become lazy and sleepy over their work.

I do not think it is encouraging to allow rapid boys to omit exercises. It tends to discourage them and make them lose interest in their work. Experience teaches us that a bright boy, full of ambition, cannot go ahead fast enough; he will soon cover the entire ground without omitting any exercises. A bright boy likes to show how quickly he can work, and the easy grading of the course gives him a good opportunity to do this.

Teaching by Experiment (Laboratory Work).

A. W. Martin.—At the Brightwood school is an experimental or proof corner. After the boys work out their problems on the blackboard they are allowed to go to the corner and prove their work. The problems, which are usually given them, relate to the capacity of air and water pumps and tanks; calculating the leverage and lifting power of hydraulic jacks and pneumatic hoists and problems where areas and pressures are considered. It is our intention to give problems relating to the compressive, shearing and tensile strength of materials. These we could demonstrate on the hydraulic jack accurately enough for all practical purposes.

A good feature in teaching this class of work is that the boy has the actual experience of seeing how the apparatus is constructed, as the lesson sheets require him to give dimensions of various parts, which necessitate taking the machine apart. After doing this he is requested to write an explanation, illustrating it with sketches, of the action of the air or water from the time it enters the pump until it is discharged into the atmosphere or reservoir. When the boy has had this experience we remove some part of the pump, without his knowledge, either leaving it out entirely or replacing it with a defective part. He is then put to work tracing the trouble and is told that he must locate it without taking the pump all apart.

Most of the apparatus used in the corner referred to was scrap, and was put in good shape by the boys during regular class hours. This work included cleaning, repairing, making new parts, assembling, installing and all pipe work. The boys are deeply interested in this work and take considerable pride in what they have accomplished. Thus far we have had no trouble in carrying on this work in the same room with the drawing class.

A. L. Devine.—We now have in the school laboratory at West Albany, for demonstrating purposes, the following apparatus: 4½ x 6 in. stationary engine, 22 in. engine lathe, gear rack, Walschaert valve gear model, partial section of 9½ in. air pump, bell ringer, safety valve, indicator and spring balances and sticks for leverage examples. The engine, which is operated by compressed air, runs the lathe by means of pulleys and belts.

Problems have been furnished us for work on the lathe, engine, gear rack, valve gear model and spring balance. These are done during school hours and corrected by the instructor, or one of the advanced boys, before the end of the exercise. Whenever possible we have the boys work in pairs on these problems. This work appeals to the ambitious apprentice, giving him more confidence in himself by working out the problems experimentally, breaks the monotony of the routine work and relieves the instructor to some extent. With an average attendance of thirty boys it is almost impossible for the instructor to devote any time to this class of work, and we have assigned one of the leading boys to take charge of everything but the drawing.

The valve gear model was made in the shop by a cabinet maker assisted by an apprentice; the forgings for the gear rack were made by a blacksmith apprentice and finished by a machinist apprentice. Two machinist apprentices removed quarter sections from several of our larger models to allow for a better view of the interior. With the exception of the valve gear model, all of the above work was done on the boys' own time.

Discussion.—At Oswego a machine has been constructed for testing the strength of materials.

The Use of Sketch Books.

H. S. Rauch.—I believe the sketch book to be one of the most valuable acquisitions we have made, for the reason that it teaches the apprentice how easy it is to omit an important dimension, or note, at a time when he cannot go back and get the information without cost to the company. The boys must be made to appreciate the fact that they are expected to get all necessary information when they are making the sketch. As to the proper time to begin sketching, it seems to me that the first model would be too soon. I think that the boys should learn the principles of drawing, the arrangement of views, etc., first. This, of course, will take some boys longer than others, so if the starting point for sketching is fixed we will have to delay it long enough for all to get a fundamental knowledge of mechanical drawing. My experience has been that it takes from ten to twenty-five plates to do this, and sometimes more. I believe that we should begin sketching much sooner than has been the general practice. At Oswego it has been our custom to begin with the seventy-eighth plate, which results in the boys having so much to think of on a "hurry up" sketch that they are liable to overlook many dimensions, whereas if they begin, say on the twentieth plate, the work will be much more simple and they will grow up with it, so that by the time they complete their course, sketching will have become second nature to them.

G. Kuch, Sr.—The use of note and sketch books was fully carried out at Depew about one year ago and good results were obtained. Apprentices were requested to sketch parts of engines, etc., draw the plan, side views, elevation and sections and add all necessary dimensions. They could then return to the drawing board and make a complete scale drawing from the sketches.

The use of note and sketch books should be enforced. Apprentices who have passed all examinations and have served six months, should obtain a note book, 2-ft. rule and soft pencil. They should then be required to make sketches and notes wherever possible. The instructor should see that these rules are enforced.

Sketching should not begin with the first model but after the twenty-fifth or thirtieth drawing. Ability to make sketches is a benefit to the company, the boys do not ask so many questions of the foreman and take his time from other important duties.

Should a Preliminary Sheet of Lettering Be Used?

C. A. Towsley.—I would suggest that a preliminary sheet of lettering be introduced into the course and that one sheet at least, and as many more as deemed necessary and advisable by the instructor, be required of each apprentice. Only about one-quarter of the new apprentices are able to do a creditable job of lettering and their ability is usually shown on the first drawing plate. Lettering is a knack that all cannot acquire, even with practice. The other three-quarters would be better off with several hours, or days if necessary, of practice in lettering or until it is evident that they have thoroughly mastered the work.

It is noticeable that a boy who is poor in lettering does not improve as rapidly as in drawing. The reasons are that the amount required is not equal to the amount of drawing, and because lettering is considered drudgery and is distasteful. Nothing detracts more from a drawing than badly formed letters and figures, and for that reason alone, extra precautions should be taken to bring them up to a standard of perfection.

Study of English.

Henry Gardner.—I am thoroughly in favor of the proposition to introduce instruction in the use of English into the fourth year of the apprentice school course.

In practical life the ability to speak and write clearly and effectively is necessary to success. No matter how thoroughly a foreman understands his work, if he is unable to make his men see his methods clearly, he is very much handicapped and cannot have the same hope for advancement which he otherwise would. A mechanic may have an application to make for a change of position or an increase of pay. If he can set forth his demands correctly and concisely, he will be more likely to gain his point than one who cannot. Inspectors and enginehouse foremen are frequently required to make reports to the master mechanic relating to repairs needed on locomotives and cars. A man having the ability to make this report brief, clear and intelligent, to state in good English the necessary information, will add to his chances for promotion.

The instruction in English should include letter writing and composition. I would suggest the following method for instructing boys in letter writing. Begin by requiring each boy to write a short letter upon some common, everyday subject and hand it in for criticism. To make this work more attractive it might be well, at times, to have two or more boys write letters upon the same subject. The instructor should then read the letters aloud to the boys, making a general criticism and comparison. Later, when proficient, it would stimulate interest to have some boys exchange letters and each criticize the letter written by the other.

The instructor should see that letters are written in well chosen, grammatical language, with a logical sequence of ideas, properly paragraphed and punctuated, and above all, each word correctly spelled. He should be careful, however, not to follow too closely the laws of composition. A boy with some origi-

nality may thus be kept from showing it. Teach the boy to say what he thinks without fear of breaking some rule.

The instruction in composition should best be done in the same manner. Common, everyday subjects close to the boy's life and work should be assigned for a short essay. As the boys advance in the work the course may be extended by making the subjects more difficult and increasing the length of the composition.

As with other branches of the school work, a text-book for the study of English would not be satisfactory. Lesson papers giving examples of the most frequently used business letters should be issued to instructors and also lists of subjects for original letters and compositions. Notes to instructors emphasizing the important points to be brought out in correcting the papers would be beneficial.

The time to be devoted to the study of English would depend upon local conditions and the advancement of the boys in the other studies. I do not think it advisable to lead the boys farther than outlined in this paper. Great efficiency in writing good English can only be had after years of practice and study, and it would not be profitable to occupy a large amount of time in such work.

Home Work.

A. L. Devine.—Shortly after the school opened last fall it was found necessary to introduce some system which would encourage the boys to do more home problem work, not only because of the small number of problem sheets handed in, but a majority of the boys were progressing too fast with the drawing. To accomplish this and to provide for a better balance between the problem and drawing work, we made an iron-clad rule that the minimum number of corrected problem sheets handed in must equal one-half the number of drawing sheets completed. At the end of each month we checked the number of problem and drawing sheets, and when not conforming to this rule we put the boys who were behind in problems at the blackboard until they had completed the required number. I may add, however, that we never had occasion to punish any of the boys for being behind in their drawing work, and as soon as they found out that we were in earnest we had very little trouble from the problem work. This arrangement retarded the drawing work but increased the problem output.

We experienced great success by giving the boys a partial answer to all the "A" series of problems. When handing out the problems we attached a blue print giving the answers; each answer having one or two figures blocked out. This gave the boy a clue to the correct solution of the problem. Data sheets are also given out with the problems. This resulted in reducing the number of problem sheets handed back to the boys for correction more than one-half, and the number handed in during the past five months has increased at least twenty-five per cent. I feel safe in saying that nothing has been done for the boys at West Albany, in connection with the problem work, which has been appreciated as much as these partial answers. I believe most of the arithmetics used in our public schools have the answers given to all examples; why not for the apprentices?

The Car Department General Apprentice.

L. T. Johnson.—The applicant must be not less than twenty years old and of an agreeable temperament and good morals. He must have a common school education and a fair knowledge of drafting. The first qualification is a necessity. A boy under twenty is not so able to absorb knowledge and to realize the importance of detail. A good disposition is important because a foreman to be successful must be popular with his men. The education required and the knowledge of drafting are necessary. The need for a good moral character is obvious. These qualifications being fulfilled I would start the boy as a blacksmith helper, keeping him there for six months. His next move would be to go to the machine shop for six months. From the machine he should go to the planing mill for six months, continuing through the various departments, spending at least six months in each. The complete term of general apprenticeship should be three or four years. At the end of this time, after following the prescribed course, the apprentice should be able to hold the position of inspector or assistant foreman.

R. M. Brown.—At Collinwood we have general car department apprentices. We take car builder apprentices and put them through the various departments, with the exception of upholstering and such like, for four years. We now have nine apprentices and give them the full course. A year ago we did not have a car builder apprentice.

The Car Shop Apprentices.

F. Deyot, Jr.—The method of instructing the car department apprentices should not differ from that of the locomotive apprentices. The subjects to be treated should not be the same, since the two departments employ men of distinctly different trades. The trades necessary to construct cars are much less difficult to learn than those needed in constructing locomotives. The degree of skill required not being the same, I would suggest that when an apprentice has reached that point in car construction where he can do all classes of work unassisted, that he be transferred to the locomotive department. The locomotive work should be considered a higher grade of study and should be included in his regular course of apprenticeship.

Shifting Apprentices.

Frank Nelson.—From results obtained during the past two years at West Albany, I consider that the best method is to shift the apprentices every three months in both the erecting and machine shops. In this way the boy is given an opportunity to learn all branches of the trade in the shortest time. The accompanying table shows what I would recommend for the four-years' course:

Time in months.	Wages.	Shop.	Class of Work.
3	Prorated with Machinist.	Erecting	Springs, equalizers, brake, etc. General work under engine.
3	" "	"	Truck work. General repairs.
3	" "	"	Steam and exhaust pipes, dry pipes, throttle valves, dome caps, etc.
3	" "	"	Cab work, blow off cocks, injectors, throttles, levers, etc.
3	Regular rate Day work	"	Boiler work, studs, etc., for new boilers and boilers with new fire boxes.
3	" "	"	Guides, pistons, valves, steam chests, cylinder heads, main and side rods.
3	" "	"	Shoes and wedges, binders, etc.
3	" "	"	Valve setting, keyways, tramming engine, etc.
3	" "	"	General floor work.
3	" "	Machine	Bench work, links, rods, levers, etc.
18	" "	"	Turret lathes, shaper, slotter, planer, boring mill, lathe, air brake or tool room.

To make this schedule effective at West Albany it would require thirty machines and bench jobs. They must be so arranged that ten boys may be shifted every month, and thus the organization should be such that one boy will follow another right up the line, commencing at bench work and continuing through to the tool gang. If such an organization could be established it would be of great benefit to the boys and would increase the output.

The slow boy should be shifted in the regular routine so that the quicker boy who is to follow him may have the full time allowed upon the machine. A slow boy who does not show decided improvement after three to six days of instruction should be taken off the machine and put on special work for which he is better suited. He should be told that the company cannot afford to reduce the output of the machine. Some boys learn quickly and others slowly. The quick boys often make careless mistakes, while the slow ones, when the idea is grasped, seldom forget it. For this reason every effort should be made to study the dull boy and bring him up to standard before removing him from the machine.

To shift out of turn not only breaks up the organization, but

it is not satisfactory to the boy. Though he may deserve some credit for quickness, if he loses the required number of hours which the schedule calls for on the machine he loses the chance to perfect himself in each branch of the work. A thorough knowledge of one subject is infinitely more valuable than a slight knowledge of many. Another reason why it is not expedient to transfer faster than the regular schedule is that it will create dissatisfaction among the men.

Boys who learn rapidly are kept in view by the foreman and are given opportunities to do a variety of work. The slower boys do not get the wide experience that rapid boys do, although in many cases they work just as hard.

J. R. Radcliffe.—If an apprentice is started on bench or floor work he should have all the experience in that line of work that the schedule calls for before he is shifted to the machine. When a boy is started on floor work, and in three months is shifted to a machine, and then is shifted back to floor work in another three months, he has not made as much progress at the end of his first year as he would have had he been kept on floor work until that part of the schedule was completed.

When possible, it is well to have the machines grouped. When a boy is started on a machine, a lathe for example, he is given the simplest work to do. The boy on the machine next to him will be doing a little more difficult work and perhaps the machine will be different. If the boy on the lathe is observing, he will catch on to a good bit of the work done on the next machine, and when it is time to shift him to that machine he will have some idea of the work and will learn faster than if the two machines had been in different parts of the shop.

If a boy has any ambition he will want to be first in his work, just as he would want to be first in his class at school. There are times when a machine run by a machinist is idle. When this occurs it is well to take a bright boy, one who has been on machine work about a year, and put him on the machine. By doing this you not only advance and encourage the boy, but the output of the machine is kept up. Bright boys are often equal to machinists. Slow boys are waked up by seeing others pushed ahead. I do not think that a boy should be held back if he shows unusual proficiency. To advance him will cause others to put forth their best efforts in order to catch up.

M. T. Nichols.—We are trying a new method of shifting apprentices in the Elkhart shop, which will do away with a great deal of annoyance to the foremen and loss of time by the apprentice and the machinist with whom he is to work.

When each apprentice to be changed checks in in the morning he receives a card telling him where he is to work and with whom. Should the boy be changed from one job to another in the same department his card reads as follows:

M. J. Donohue—Report to E. U. Dow on guides.
Check No. 98.

In case the machinist is laying off, the apprentice reports to the foreman. If he is to be changed from one department to another his card reads as follows:

Wm. Boardman—Report to C. F. Jacobson, Foreman, for bolt lathe.
Check No. 140.

By using this card the apprentice knows immediately where he is to go and goes to work at once, thus doing away with all visiting or killing time. In the old way, the foreman took an apprentice away from a machinist and sometimes delayed an hour or more before bringing him another boy. During this time the machinist was without help, which might be a serious loss to him if working piecework. The loss to the company is also apparent.

Another difficulty is overcome by the card system of shifting apprentices; under the old method a boy due to go from the machine shop to the erecting shop might be held back by the foreman to finish some job. The erecting shop foreman meanwhile is short one boy, having let him go on the day scheduled for the change. The effect of this is that the erecting shop foreman will refuse to advance a boy until he receives another in his place, thus delaying the boys all along the line. Each foreman will receive a copy of the changes a day or two before they are made. It will be the duty of the shop instructor to check up the apprentices on the morning of the change and see that they are all in their proper places.

The Relation Between the Instructor and the Apprentice.

The instructor should study the personality and character of each boy and strive to gain his confidence. Every one of the boys is at times going to get the blues and possibly become discouraged, and the instructor's attitude should be such that they will instinctively turn to him for advice and encouragement at such times. That several of the instructors have been especially fortunate in this respect was indicated by the discussion of this question.

Talks By Company Surgeons.

C. P. Wilkinson.—A series of lectures by the company's surgeons would result in much good to the apprentices. The talks should not be given too frequently and should not be too long. I would suggest first taking up the subject of the care of the injured, explaining it so that the boys could understand and remember each rule to be followed. The question might be raised as to whether it would be practical to have the talks during class hours; it would depend somewhat on the surgeon's other engagements. Anything of this nature might better be given after shop hours and to the class as a whole, thus avoiding all interference with shop work. If it is desired to hold lectures during class hours and for all the boys at once, the shop end could no doubt be taken care of.

The Apprentice Exhibit at Atlantic City.

Mr. Rauch described this exhibit and told of the attention which it attracted and the impression which it evidently made on those who examined it carefully. In closing he said: "The thing that struck me most forcibly was the simplicity of the whole apprentice scheme, the inexpensive equipment, and the broad field from which we can draw models and demonstrating paraphernalia. About all we need is a good, well-filled scrap bin to meet nearly all of our requirements for models used in the drawing class and demonstrating room. Another feature, and a most important one, was the shop work exhibit, which proved beyond a doubt that the inauguration of the shop instructor is an indispensable feature in the apprentice organization. This work, some of which was done by first and second year apprentices, was equal in quality, and in many cases was performed in as short a time, as if done by a skilled mechanic."

Topical Discussions.

Should the Question Box Be Introduced Into the School?—The general opinion was that it should. Boys who are naturally shy will be encouraged to ask questions. The instructor will get a line on troublesome problems which bother the boys and will be better able to help them. It costs nothing to try it. The time to be devoted to the questions could be limited to fifteen minutes, and they should be presented at the beginning of the second hour, when a little diversion from the drawing would be agreeable. The questions should cover all school work, both drawing and mathematics, shop work, locomotive construction and engineering. A question could be read and any member of the class given an opportunity to present his views, after which, if not satisfactory to the instructor, it could be given to some member to look up and present at the next recitation, or could be explained by the instructor.

Apprentices as Instructors (H. S. Rauch).—At Oswego we have always had an apprentice for assistant drawing instructor, and the scheme has worked out nicely. When a boy is picked out for an instructor good judgment must be used, as the brightest boys do not always make good instructors. When once selected, the boy must have special training in maintaining discipline, etc. By following this method we have had very good success in using apprentices for instructors.

Shop Discipline.—In discussing the question, "Would it be more effective to refer all cases of shop discipline to the superintendent of shops?" the opinion was that only the most aggravated cases should be thus handled and only as a last resort.

Higher Rates for Boiler Makers and Blacksmith Apprentices.—The difficulty of securing apprentices in these trades is largely overcome by increasing the rate of pay over that paid to other apprentices.

Special Courses for Molder Apprentices (C. A. Towsley).—Great difficulty is experienced in obtaining a boy with a fair education, willing to take up this work, and the result is that out of the four or five apprentices who have started, all have quit or been dismissed.

In a general way the following items might be introduced into our present course, so that it would appeal to the average molder apprentice. Problems dealing with weights of iron, brass, and white metal castings, sand, coke, etc. Estimating weights of castings without and with cores. Estimating weights of castings from patterns, both by weight and cubical contents. Give weights of grades of molding sand, both loose and rammed, dry and wet. Capacity of different size cupolas. Figuring charges for different weights of castings to be poured. Figuring amount of charge for pouring a floor. Charges for different mixtures of iron. Proportions for core sand. Amount of flour for different core mixtures. Ladles of different shapes and sizes, their capacity, etc. Questions relating to use of materials, tools, mixtures and operations, which would be obtained from actual practice.

The drawings should include portions of our present course, which are suitable, together with drawings of solid castings, cored castings, machine and locomotive castings, flasks, ladles, molds and cupolas with charges in place. Sections of various shaped castings in the molds could be drawn.

The Graduate Apprentice (H. S. Rauch).—It has been my experience that the graduate apprentice, if given a fair rate of pay, usually sticks to the company. Of ten apprentices who have graduated at Oswego shops within the last two years, nine are now working for the company. Heretofore the apprentice has drifted out of sympathy with his employers by reason of the indifference displayed toward him by those having him in charge. To offset this tendency he must be made to feel that the employers have his welfare at heart, and this can only be accomplished by having not only a good apprentice training system, but the service must be made attractive to him after graduation.

A TALK TO SHOP SUPERINTENDENTS AND GENERAL FOREMEN.

By Robert Quayle.

(Editor's Note.—*An address on this subject, coming from Mr. Quayle, must carry great force. Although the main repair shops of the Chicago & Northwestern, at Chicago, are between 30 and 40 years old and without many of the improvements which are regarded as essential in modern shop plants, yet it is generally recognized that it is one of the best equipped and organized railroad repair shops in the country. Not only this, but the efficiency of the motive power department, as indicated by the annual reports, is approached by but few other roads. The following extracts have been taken from an extemporaneous address which was made at the opening of the recent convention of the International Railway General Foremen's Association.*)

In your shop repairs you ought to get down, not to what it has cost you, but how does your cost now compare with other roads. Is the cost for repairs on your road 3½ cents a mile, or 4. or 5? If it is 5½ cents a mile on any road in this country, it is too much. It is out of proportion with what other railroads are doing and what they can do and we ought to know these things. I believe that to have an intelligent supervision of work, we must have an intelligent idea of the cost of the work; not only of the supervision so far as the fixed charges are concerned, but of the different processes and methods that this work is going through and what each process is costing, and we want to know whether we cannot introduce some other method that will be very much cheaper and better. The man to-day who builds a little fence around himself and becomes isolated in a large degree and thinks: "This shop of mine over which I have supervision is all right and the set of men that I have about me are the only men, and we are It"—when a man begins to feel that way, he is a back number. The world is making such progress that if we go away for six months or a year and then come back we find we are back numbers. The other fellows who have been in the harness doing the work while we were away have outstripped us in the race. We are making such rapid strides that we have to keep continually at it in order that we may stand a little bit in the front. On the other hand, I do not believe that we ought to be too modest about these things. It is just as bad for a fellow to be too modest as for a fellow who thinks he is accomplishing it all.

MEN MUST THINK.

The first essential toward the success of a man is for him to think, and think clear down through whatever problem is before him. The man who takes up air brake mechanism must first begin with the atmosphere—the component parts of the atmosphere; he must understand what the pressure of the atmosphere is. He must follow it through the engineer's valve—through the triple valve, and so on; he must take a little wire and trace it from the time it is received into the pump. He must know what the functions of the different pieces of mechanism are and have an intelligent idea so that if anything goes wrong he will know where to look for the trouble; this man is equipped to accomplish something in a moment's time. So it ought to be with you and so it ought to be with me.

You are filling positions because of your alertness—because of your intelligence and because you have shown to the man, who in position is your superior, that you have something in you that the other fellow did not have, and he says, "This is the man we want to promote, because he has qualifications that will make us an efficient man and he has the ability that will help to raise other men up to a higher efficiency." If that be true, you men as superintendents of shops or general foremen ought to get about you men of intelligence—men of rare qualities and ability who will see things and be able to eliminate and cut out all the unnecessary movements that are being made.

You see a man in your shop take a certain piece of work and go from the machine shop to the tin shop—the man has to travel several hundred feet and back. Why not have a little machine do all that cross-head work right where the cross-head is being fitted and save all this going back and forth? These are things that count. Where you have a shop, and have charge of two or three thousand men, as some of you may have, you can readily see that the unnecessary movements of these men amount to a good deal. Your office is to know that these men are not making any more movements than absolutely necessary. It means labor to walk back and forth—it means effort on the part of the men; instead of putting that effort into useless movements, put it into things that count. If you have been advanced to a position because of your intelligence, how much of that intelligence are you imparting to the under fellow? Is it your method to find fault with a man because he isn't doing the work as good as you? You cannot expect that a fellow who is getting $80, $90 or $100 a month to do as much work and to do it as intelligently as the man who is getting $150. He hasn't the same opportunities that you have and it ought to be your business and my business to get these men who are under us (we call them subordinates) in front of us, and have certain stated times to discuss ways and means; your superior intelligence, knowledge and ability ought to, in a very large measure at least, lift these men up into a higher standard of usefulness to you, and when they are working for the company and getting better results they are helping you. Do not find fault with a man because he is not doing a thing, but question him: "Don't you know a better way of doing this?" Do it in a thoughtful manner and get the other fellow to think. What we want to do is to get men to think.

Take premium work and piece work. A man realizes that he is simply a machine—a factor in this world, and his only aim is to accomplish a certain amount of work on certain lines and in

the accomplishment of it he is going to bring to himself larger returns. He begins to study how he can do more of this work with less effort on his part and how he can accomplish more work and bring to himself greater earning power. He begins to think. It is that thought that will better his wage earning power and it is that thought which will lead to your success. How many hours have you put in after you have gone home nights studying how you can improve your men and how you can broaden your views so that you can help yourself? Man is a selfish being, and if for no other reason we ought to study the situation for self. Take the big men of the world to-day. Why are they filling high positions? Is it because somebody boosted them into the positions? Count the men that you know who did not have any more opportunity when they started than you had. Those men have simply come into their positions because, as Shakespeare says, "There is a tide in the affairs of men which, when taken at its flood, leads on to fortune." When the opportunities came they plunged into the tide and went on to success. We were needing a man for promotion, and I mentioned a certain individual to our shop superintendent. He said, "That man can neither read nor write. He stands in his own light." An intelligent man otherwise, who in this generation does not know how to read or write! When he was a young man he ought to have been burning the midnight oil. Gladstone, after he was seventy years of age, mastered the Greek language, and I think there isn't any one in this room to-day who is not able to master higher mathematics.

You have these men about you and you should ask them why they are doing such things so and so. If they are turning off a piston rod, ask them why they do not grind it. Is it possible that in thirty years there has been no improvement in this line? Do not drive it into them in a rough manner, but in an intelligent way, and they won't feel that you are clubbing them. A club over your head don't do you any good and if you have a man who has to have a club over his head, get rid of him. When a man feels that you are driving him, he gets discouraged and don't care; you drive away his usefulness and his interest, and when his interest is gone he is no good to himself or to anybody else. Encouragement ought to be the shop motto. Get every man to do the best he can and to lift himself up to the highest point within the limits of his ability.

EFFICIENCY.

We have a shop that was built in 1872 and occupied in 1873. The shop, so far as its physical condition is concerned, is no doubt what you would term a back number—the construction of it is such. We have twenty-one available stalls and yet have no trouble in getting sixty-five locomotives in for heavy general repairs, and we can run it to seventy if necessary, and do it economically. The fellow who doesn't get economy will simply have to get down and out, I do not care what his name is.

I note a paper on your program about the different forms of construction of a shop for a transfer table. It is a good thing to think upon these matters so that when you are called upon you may be able to give an opinion; but my duty and your duty more particularly is to do the best we can with the tools and the conveniences that are at our fingers' ends. It does not do for you and me to sit down and talk about what we could do if we had all these facilities, but what we can do and ought to do with the tools that we have.

You will be surprised when you get at the thing right to find what can be accomplished with old methods. We should get busy and study it out. In our shops, Oscar Otto has a plan. Every Monday morning at eleven o'clock he calls his men about him and they go over the work of the past week. He will say, "We ought to have gotten out fifteen engines last week, but I find that we only got out fourteen; something is the matter." A representative of the store department is there and he talks about the material; in discussing the matter, they put the responsibility right where it belongs. The man is there with his associates, and he feels keenly the position, although all remarks are made in a spirit of kindness. The next week it may be some other fellow. Sometimes a delay has been caused by something over which he had no control and the responsibility is passed on to the responsible party. It may have been up to the superintendent of the shops; if so, he is held accountable for the unnecessary delay. It simply strings these fellows up with such a tension that they will next week profit by the failures of last week.

When these men in the shops find that they have failed in certain things, they take a little pride in not having it occur again. I do and you do. It is human nature. It is in every fellow. If he has any respect for himself he wants to do as much and just as well as the other fellow. That is true, and you can do that by getting these men around you and injecting into them the right spirit, and if you haven't the right spirit in yourself, just go away in the woods and hate yourself a few weeks and come back and say, "I am all right." If you are going to get the highest efficiency you must train your men and you must help them. I get my master mechanics about me every once in so often and we talk about various things and they give me lots of information. They hit the old man pretty hard many times, and I say, "Come on. I am here for that purpose." I am not putting on my mittens to defend myself. They just want to hit me a square blow, and the harder they hit me the better I like it, simply because of this fact. What is my position? It is simply a man—a little pivot around whom the organization swings. If the organization cannot accomplish more than the man at the head of it, it isn't a very good organization. The man at the head of it can instill into his men such characteristics as will get at the very best results, and he does it in such a manner as will inspire and instill confidence, and if the men feel that he is a helping friend—that he is a fellow to whom they can go with their troubles—they will be ever ready to assist. Get the men to love you and you will get the men to work for you; they will come to you with all their troubles and then you will begin to eliminate all those things that are wrong. The superintendent of motive power, the master mechanic or the general manager of a railroad who sets himself up on a pedestal so that his men cannot approach him on these matters is a failure. If that applies to the general manager, how much more it applies to you who have the men approach you every day.

FAITHFUL APPLICATION TO WORK.

You were not the fellows who, when the whistle blew, threw your hammers up in the air; you simply finished what you were doing and did it well. I came here to talk to you just the same as I would talk to the men in our own shop. The motive power men of this country depend upon you and look to you for the men who are going to fill the positions on the railways. You are the fellows who must fill the positions by diligent, faithful, earnest application to the work that you have in hand.

I take great pleasure in the thought that in so far as the motive power is concerned, it is not I, *but the men who are associated with me,* are working with me and assisting me in every way possible to make it a success, and they are helping themselves. If any of you think that the superintendent of motive power is the only fellow, get it out of your heads. He is only a little factor and they get him on their shoulders and they pass him along and keep carrying him along. It is a continual delight to me. Why should not I get around these men and help to lift them up—make them more useful to themselves and their fellowmen? Would I be a man if I did not? If that is true of the superintendents of motive power, isn't it true of you?

Waste of Locomotive Fuel.—Coal wastes on railroads are almost as bad as labor and material wastes. On a very large railroad system, fuel charged per 1,000 tons of train weight per mile averaged 260 pounds; yet actual tests, where all coal used was weighed, showed a consumption between terminals of only 80 pounds. This actual consumption could be doubled, be made 160 pounds, yet this standard be only 60 per cent. of the actual wasteful expenditure.—*Harrington Emerson in The Engineering Magazine.*

The number of miles of railroad per 10,000 inhabitants in the United States, June 30, 1906, was 26.78 as against 26.44 for the previous year.

(Established 1832).

AMERICAN ENGINEER AND RAILROAD JOURNAL.

PUBLISHED MONTHLY

BY

R. M. VAN ARSDALE

140 NASSAU STREET, NEW YORK

J. S. BONSALL,
Business Manager.

R. V. WRIGHT, E. A. AVERILL, Editors.

OCTOBER, 1908

Subscriptions.—*$2.00 a year for the United States and Canada; $2.50 a year to Foreign Countries embraced in the Universal Postal Union.*
Remit by Express Money Order, Draft or Post Office Order.
Subscription for this paper will be received and copies kept for sale by the
Post Office News Co., 217 Dearborn St., Chicago, Ill.
Damrell & Upham, 283 Washington St., Boston, Mass.
Philip Roeder, 307 North Fourth St., St. Louis, Mo.
R. S. Davis & Co., 346 Fifth Ave., Pittsburg, Pa.
Century News Co., 6 Third St., S. Minneapolis, Minn.
W. Dawson & Sons, Ltd., Cannon St., Bream's Buildings, London, E. C., England.

Advertisements.—*Nothing will be inserted in this journal for pay,* EXCEPT IN THE ADVERTISING PAGES. *The reading pages will contain only such matter as we consider of interest to our readers.*

Contributions.—*Articles relating to Motive Power Department problems, including the design, construction, maintenance and operation of rolling stock, also of shops and roundhouses and their equipment are desired. Also early notices of official changes, and additions of new equipment for the road or the shop, by purchase or construction.*

CONTENTS

FRAME BREAKAGES.

The article entitled "The Dynamics of Locomotive Machinery," on another page of this issue, throws some light on the subject of locomotive frame breakages. The enormous forces to which parts of the frame are subjected, under certain conditions, is surprising and the wonder is that there is not more trouble due to frame breakage. In this connection the importance of having the metal properly distributed, in line with the action of the forces, cannot be too strongly emphasized, as even a slight eccentricity increases these stresses greatly.

An investigation of this kind will be found equally useful for the solution of other important problems; the perfection of the counter balances and the effects of steam distribution may be studied graphically, and the locomotive designer is enabled to more intelligently design the rods and guides, the bolting of the cylinders and boilers to the frame, etc.

BOILER MAINTENANCE.

The results of the experiments by J. F. Whiteford, as described on another page, bring out some significant facts concerning the care of boilers at terminals. Undoubtedly the matter of boiler maintenance has not been given the attention which it should have had in the past. We have in mind one road where the conditions were very bad and boiler failures were a matter of daily occurrence, in many instances seriously interfering with the passenger schedules. The officers in charge of the motive power department were competent, but overworked. Conditions finally became so bad that it was absolutely necessary to give it proper attention. A few months of careful and systematic effort worked wonders, not only eliminating failures, but greatly reducing the cost of boiler maintenance. There are a number of roads which to-day have fewer boiler makers on their payrolls than they did five years ago, although they now have considerably more power. Results are possible at the expenditure of a reasonable amount of effort and this is only another instance of work which should be studied and in a general way supervised by a member of the superintendent of motive power's staff who can give his entire time and attention to it.

APPRENTICE INSTRUCTORS' CONFERENCE.

The proceedings of the second annual conference of the apprentice instructors of the New York Central Lines, an abstract of which appears in this issue, indicates that the work of the apprentice department has become firmly established and that a very considerable development has taken place since the conference of a year ago. One need only to study over and compare the subjects which were discussed at the two conferences to note that a number of the small details which seemed to give considerable trouble to the instructors a year ago have apparently been settled and adjusted, and in some instances almost forgotten. As an example, one of the most troublesome problems discussed at the first conference was "How to get the boys to do a reasonable amount of home study." There has been a very noticeable improvement in this matter at practically all of the shops during the past year.

When the apprentice department was organized it was with the idea that the practical results which would accrue to the company would not appear for several years, or at least not until sufficient time had elapsed to graduate thoroughly trained apprentices. It must give those officers who were responsible for the installation of the department, and who had so great faith in its future possibilities, considerable gratification to see the practical benefits which have thus far appeared, although the system has been in operation less than three years. Another feature which cannot be viewed but with satisfaction is the interest which the boys themselves have taken in the development of this work and the ready response which the efforts of the company have met with on every side. The installation and carrying on of this work on the New York Central Lines must

have cost considerable and yet it is doubtful if the same amount of money expended in any other way could produce so great results if we consider only those benefits now apparent and leave out of consideration the very much greater advantages which will surely result in the future.

ORGANIZATION.

A number of years ago a superintendent of motive power of one of the larger systems was severely criticized for adding to his organization a number of so-called specialists, each one of whom was detailed to make a special study of and give general supervision to a certain part of the work, such for instance, as boiler work, roundhouses, fuel economy, etc. During recent years a few roads have taken up this idea to a greater or less extent, but in most cases it is not being used nearly as effectively as it might be.

It seems to be generally acknowledged that there are very great possibilities of saving in the matter of locomotive fuel, and yet how few roads are making any systematic attempt to follow this matter up. In several instances attention has been focused on one or two phases of the fuel question, and while good results have been obtained, yet the really big savings are not made, because in most cases no one person is responsible for following up and supervising this work. The general officers of the department are ordinarily burdened with so many routine duties as not to admit of their making more than spasmodic efforts to secure these economies. As a matter of fact, there are only a very few roads having a man in charge of the fuel question who makes it his business to follow the coal from the time it is mined until it is used in the locomotive. The fuel question is here used only as an illustration. There are a number of other features in the motive power department which require the same treatment. The roads have grown so fast that they have hardly had time to adapt their organization to meet the larger problems which have developed, but surely it is time to do so.

A. M. Waitt, in an article on "Some Thoughts and Suggestions on Railroad Organization and Management," which appeared in the *Railroad Gazette*, March 11, 1904, had this to say: "In railroad organization, for large systems, more of the military type of organization is needed, both in the way of a general staff for assisting the chief executive officer and also a corresponding departmental staff for the assistance of the department chief." In a brief summary at the end of his article Mr. Waitt mentions a dozen or more items which are necessary in an efficient organization, one of which is as follows: "Chief executive officers and department chiefs to have a sufficient staff of able men to relieve them from routine and detailed work, and also to have a corps of assistants who are free from confining routine work who can be assigned to special investigation of important matters in department work."

Harrington Emerson, in one of a series of articles on "Efficiency as a Basis for Operation," in the September issue of the *Engineering Magazine*, draws attention to the strength and weakness of existing systems of organization. In general these are of two distinct types, line or staff, or a combination of the two. The line may be illustrated by the earlier methods of army organization, before the general staff was added. Some one was always ready to assume the command no matter how many of the men or officers may have been destroyed. Such an organization is practically indestructible. The objection to it was that the promotion was strictly by seniority and not by merit, and no one officer knew much more than the others. It was the addition of the staff to the line which enabled the Prussian army under Von Moltke to overthrow the combined armies of Austria and Southern Germany in an exceedingly short campaign, thus making possible a united German kingdom, which in turn defeated the French in a campaign of less than two months.

In the staff organization the men who are specially well equipped and adapted for certain lines of work are selected and placed in charge of that work. With their superior knowledge they are enabled to secure the best solution to the problems which are referred to them and, where the staff is used in combination with the line, their findings are turned over to and put into effect by the line organization. Mr. Emerson's idea is that the best results are secured by a combination of these two types of organization, the two branches working as much as possible in parallel. In this way the lowest paid workman in a large organization will have the benefit of the special knowledge of a staff of experts.

The problem of efficient organization is the most important one which at present confronts not only the motive power department, but all departments of the railroad. A paper on this subject which is to be presented by J. E. Muhlfeld, before the New York Railroad Club at one of the winter meetings, will be awaited with interest.

REPORTS ON CONDITION OF POWER.

At a conference of motive power officials on a large system a rather spicy discussion recently took place as to reports on the condition of power. A mathematical analysis of some of the statements which were made showed that they were simply ridiculous. The discussion prompted one of the officials to send us the following notes:

"Engine condition is commonly reported as good, fair, and poor. The definition of these terms is usually as follows:

"Good engines are those whose condition is such that they can run for six months or more before shopping.

"Poor engines are those whose condition is such that they must be shopped in one month or less.

"Fair engines are those that are neither good nor poor.

"Assume that engines are in service twelve months or one year between shoppings, and that the time required for shopping is thirty days, or one month. The future record of an engine just out of the shop should then be:

"For the first six months, good; for the next five months, fair, and for the next month, poor. This accounts for twelve months, and according to the first assumption of twelve months between shoppings, the engine should now be ready for shop. At the end of thirty days the engine should again come out of the shop and the same cycle be repeated. Thirteen months makes the complete cycle.

"The ideal state of affairs exists as to condition when engines are coming to the shop in a steady, constant flow from month to month. This is much better than a spasmodic shopping of five per cent. one month and twenty-five the next, which is not uncommon.

"Returning again to the assumption of twelve months between shoppings and one month per shopping and assume also a division having a total of 130 engines. Ideal conditions then would be at any date:—

10	engines in	shop	= 7.7%
10	" "	poor condition	= 7.7%
50	" "	fair "	= 38.5%
60	" "	good "	= 46.1%

"We thus have a check on the per cent. of engines that should be in the various grades of condition. Any report which shows over 46.1 per cent. of the power in good condition, and yet shows the per cent. of engines shopped from month to month to be averaging from seven to ten per cent. is a fudged statement.

"Twelve months between shoppings is none too small a record for many roads. Yet roads making this average are trying to have master mechanics keep from sixty-five to seventy per cent. of their power in good shape. This is proven above to be an impossibility. The only way to accomplish it is to change the definition of "good," or else get more months service between shoppings.

"If the months between shoppings be increased to eighteen, the other assumptions remaining the same, the ideal conditions on a division would be:—

5.3%	in	shop.
5.3%	"	poor condition.
26.3%	"	fair "
63.1%	"	good "

MAINTENANCE OF LOCOMOTIVE TOOL EQUIPMENT.

By Robert H. Rogers.

One of the most vexatious problems for motive power management in general is that of keeping the tool equipment of locomotives to the required standard. The term equipment is flexible; on many roads it applies only to small tools, oil cans, etc., which the engineer may or may not require for use on the trip, while in other instances it may be taken to mean everything "loose" on the engine. No matter, however, what may be the interpretation it is usually a source of considerable trouble, to say nothing of a comparatively large and, in many instances, an unwarranted yearly expenditure.

When a new or a repaired locomotive is placed in service it is equipped with the tools called for in the company's specification, a copy of which is often framed and secured in the cab. The equipment is distributed in different boxes, one or more of which may be sealed, as they contain tools only for emergency use, and the others provided with locks, the keys being in the custody of the engineer for the trip. On all roads instructions regarding the manner in which the equipment shall be handled and accounted for in the case of loss or damage, are couched in such unmistakable wording that there would seem little room for confusion or evasion; but actually the practice becomes the antithesis of all carefully builded plans.

It is a fact beyond dispute that on a very large proportion, probably over one-half of the locomotives in use in this country, scarcely a single tool remains in the boxes after six months' service, even admitting that the engine in question is handled by a regular crew. In the case of a pooled engine, few remain after six weeks. There may be one or more screw jacks, with galled threads, and a dilapidated wrecking frog or so on top of the tank, but all locks, hasps, seals and even hinges have long since disappeared from the boxes. If the latter contain anything at all, the inventory may reveal a broken flat chisel and a sprung monkey wrench without a handle, this wrench also performing the office of a hammer when needed. Such conditions, of course, do not apply to all roads, as many of them do well in maintaining their equipment, but on many others they fit to a nicety.

This deplorable state of affairs has a much further reaching influence than may become apparent at first thought. The tools named in the specification represent a carefully considered selection of what is required to meet any ordinary emergency. If the assortment is complete, the engineer, in the event of a breakdown, may effect temporary repairs and proceed in a few minutes, whereas an hour may be lost if the equipment is short. Instances are innumerable where exaggerated road delays may be traced directly to such a deficiency.

Not long ago, on an Eastern railroad, an engine lost the nuts off one of the crosshead pins. With the proper wrench, or even a hammer, the engineer could have removed the jam nut from the pin on the other side and continued his trip with one nut on each pin. It so happened that no tools of any description were available and a long delay ensued, involving also a limited, extra fare, train. A number of instances are recorded where an air pipe has broken off at some union due to vibration and the engineer has been unable to make use of the thread remaining on the broken pipe as he had no means of screwing it into the union. The master mechanic, in such cases, cannot justly censure the engineer for failure to take advantage of the situation, and the engineer knows it. In consequence he may become indifferent generally to the supreme importance of getting his train moving as soon as possible after a slight breakdown.

These facts are, of course, well known to all motive power men. It is quite a rarity in reading the stenographic notes of an inquiry into a serious engine failure, not to find the engineer quoted somewhere with this remark: "I wouldn't have been there so long if I had anything to work with," and altogether too often his excuse is well taken.

The situation has indeed become so bad, that even with the thoroughness of these days in the handling of all details of railway management, it has apparently been abandoned by many motive power chiefs as a problem hopeless of solution. The amount charged directly to maintenance of locomotive tool equipment has grown into such proportions that more than one road refuses to recognize or evades the proper charge in a manner which serves to wipe the account out altogether.

The explanations of the enginemen to account for the loss and the reasons for renewal are varied to a degree. It has been said that the engineers do not take proper care of the tools; that they fail to lock the boxes on arrival at the other end of the division, and the tools are stolen while the engine is at that end. The fireman is said to throw his shovel away after the first trimming of the edge by the blacksmith, and also the fire hook when it becomes burned or needs repairs. Any case of shortage is, of course, always investigated, but such investigations as a rule are superficial and do not reach the seat of the trouble.

It is not impossible to handle this trying proposition. The problem of keeping tools on the engines can be resolved into a simple, if not a pleasant, matter in its details if inaugurated on the proper basis and intelligently handled thereafter.

The principal items for consideration should be as follows:

(1) Simplify the existing equipment.

(2) Be sure that each new engine, or each repaired engine is put into service with each item of equipment.

(3) Have the equipment thoroughly checked previous to each departure from the home terminal.

(4) Insist on the co-operation of the division points at which the engine turns.

(5) Have a check on the entire procedure, and make each delinquency a matter of record.

(6) Impose discipline for violation of rules necessary to preserve the tool system, as would be done in the instance of other recognized rules.

Simplifying the equipment is naturally the primary step. This should be taken to mean the elimination of superfluous items, and so far as possible have one item perform the work of two or more. For instance, confine the item of monkey wrenches to one 18 in. monkey wrench, cut out the crank pin block on engines which have a collar on the main pin, clamp the valve stem clamp on the stem and let it ride there until needed. Many other points of a like nature will suggest themselves when the matter is thoroughly gone into. It is a requisite for a satisfactory working of the system that, when the different items are finally decided upon, each engine should receive full equipment. If an item or two is missing it is preferable to postpone the inauguration of the system until everything is on hand.

Intelligent tool checking is one of the bulwarks of any system and a special man should be used for this purpose. With the engines once equipped and the various items in the boxes assigned to them under the framed specification, it is possible for one man to check one hundred engines per day. It is not necessary, of course, to disturb the sealed boxes. The checker's report of the engine should be a matter of record. All newly equipped engines will, of course, be "O. K." on his report, and the general record will commence with the first trip.

Co-operation with division points may be illustrated by the following example. Engine 508 leaves its home terminal, for a trip, with equipment certified to by checker as "O. K." The storekeepers at all turn-around points have been instructed by the master mechanic to wire the division headquarters if any material is drawn from their storehouses by one of his engineers. The storekeeper, however, is not to refuse the order. Engineer Brown, of engine 508, draws one fire hook at a turn-

around storehouse, also one 18 in. monkey wrench, and the fact is known at the terminal before he returns.

He accordingly finds the following form in his letter-box when he does reach the home terminal:

ROME & PARIS RAILROAD CO.

Rome Mar 14 1908.

Mr. John Brown engineer, train No. Extry engine 508

Dear Sir:-

I am advised that on your last trip last you drew from the storeroom at Paris the following items of locomotive tool equipment:

One (1) fire hook.

One (1) 18" Monkey wrench

Please advise promptly, using ruled space on this form below, necessity for above action, your tool equipment having been checked as correct previous to your last departure from Rome.

Yours truly,

Richard Roe

M. M.

Reply to above:- When fireman Smith went to throw fire hook on top of tank it fell off at Millers Junction.

In regard to monkey wrench I had to draw one in Paris because it was gone when I started to get engine ready. I locked tool boxes and went to supper and when I returned the box was broken open and wrench stolen

John Brown

Date 3/15/08 Engineer.

It is, of course, up to Brown to make some explanation on this form, which will be followed with the same care characteristic of all railroad correspondence, and no matter what he may say a clew is at once afforded for a satisfactory handling of the matter. In this illustration the master mechanic or foreman at Paris would be promptly advised that the Rome engines were having their boxes broken open at his terminal, citing a specific case in point and fireman Smith would no doubt be censured or disciplined for carelessness resulting in the loss of the fire hook.

The possibilities of this form are infinite, but it should be borne prominently in mind that its usefulness cannot be fully demonstrated unless the engine in question is completely equipped before leaving the home terminal. It is indeed astonishing and gratifying to note the results which can be quickly brought about by adhering to this general plan as outlined. Through it the author in less than three months straightened out the most unsatisfactory situation possible to imagine, with pooled engines and practically no equipment to start with. It effectually eliminated the engine crews from consideration in regard to loss or damage of tools and narrowed the inquiry to the points between which the engine ran, at the same time often affording a positive clew to determine who was at fault in connection with those terminals.

On arrival at his home terminal the engineer should deliver the keys of his boxes to the engine dispatcher or roundhouse foreman, who will hang them on a board in his office where they may be under constant observation and cannot be taken from their hook without his permission. In other than the home terminal, especially if a turn-around point, the engineer after carefully locking the boxes should retain the keys, this, of course, on the presumption, which is usually a fact in practice, that he will return with his own engine. A thorough checking of the equipment at the home terminal should suffice, and this should not be necessary at the turn-around or other end of the division.

This simple plan may be adapted to any railroad and developed to meet the requirements of any volume of traffic. The knowledge on the part of the employees that the tool question is being closely followed up by the management never fails to result in a permanent improvement.

* * * * * * *

[EDITOR'S NOTE: *This subject was discussed at the last convention of the Railway Storekeepers' Association and several valuable suggestions were made by members presenting papers on it. Abstracts from two of these are given below.*]

BY A. T. SEXTON.

Economy in the use of tools and supplies entrusted to locomotive and train crews is an important matter confronting railway managements of the present day.

This subject has been very ably presented in some recent articles by Mr. E. Fish Ensie.*

Notwithstanding all the precautions on the part of the management, those engaged in train service regard tools and supplies in a large measure as common property, appropriating whatever may best suit their convenience from one equipment to another, or from supplies in transit. This tends to mar the efficiency of the train service, as some crews are over-provided with supplies while others are markedly deficient.

Numerous instances arise where scrap brasses and defective air-hose are left on the right-of-way after applying new ones; also tools, frogs and switch ropes are often left after being used.

To obviate these conditions and care for the necessary requirements with efficiency and judicious economy, I would suggest that the practice of locomotive and train crews drawing tools and supplies, be entirely abolished; that a responsible person of intelligence and good judgment be stationed at all large terminals, for each department, clothed with authority to check up the locomotive and caboose equipments with the audit sheets, hereinafter described, after each round trip—switch engines each day during the noon hour—supplying and properly charging any articles that may be deficient. At the smaller points this duty could be performed by the car, roundhouse foreman, or any other person whose duties would admit of it. At the large terminals, the person entrusted with these duties would carry a petty stock of emergency supplies. An emergency slip should be provided for supplies drawn en route and a record sent the checker in charge of the supplies at the home of the engine.

In this connection a printed list of the items, constituting an equipment and approved by the management, should be provided in duplicate for each locomotive, caboose and passenger train box or locker, the duplicate list to be held by the person having supervision over the checking and issuing of supplies for the department in question.

The audit sheets would provide columns for:

1.—The items constituting an equipment.

2.—Tools on hand the first of the month, and their value.

3.—Tools drawn during the month, showing day and date.

4.—Total of tools drawn during the month, and their value.

5.—A daily register of the crew in charge.

Under this plan fifteen minutes or less would be required to check the supplies of an engine, ten minutes for a caboose.

I maintain by instituting a system of this description a marked saving can be had over and above the additional cost of checking and furnishing the tools and supplies.

Delays in the departure of trains incident to crews drawing equipment at the last moment would be eliminated.

Tools admitting of repair would receive prompt attention and a high standard of efficiency in the train service would be attained at a minimum expense.

Employees would enter upon their duties with greater assurance, knowing they were in possession of the necessary tools and supplies in good order, thereby diminishing wrecks and protecting life and property.

The audit sheet in this compact form would afford valuable information for the management at all times, open the way for commendation to the frugal locomotive and train crews, and

---

* See AMERICAN ENGINEER, 1908, January issue, page 7, and March issue, page 90. See also AMERICAN ENGINEER, 1905, November issue, page 412.

bring into the lime light those not acquainted with the definition of economy.

By C. L. Warner.

The greatest difficulty to overcome in the effort to effect proper use and care of tools and supplies we find is, primarily, lack of knowledge of the value of the materials upon the part of the employee in whose hands the materials are placed, with the consequent carelessness in their use and protection, and the difficulty of definitely locating responsibility for waste.

The most simple, inexpensive and effective plan or system that has come under my observation for checking tools and supplies issued from stock, and the caring thereof is herewith set forth:

First: A suitable building should be furnished at terminals, properly fitted with shelving, for caring of engineers' tool boxes, hooks placed in the ceiling and side walls for hanging thereon lanterns and scoop shovels. Blue print herewith showing interior arrangement of shelves and hooks. The oil house could be arranged and readily adapted for this purpose, provided it is spacious.

Second: Each individual engineer should be provided with a tool box, his name printed thereon, made preferably of No. 24 galvanized iron, outside dimensions of box 19⅞ inches by 5⅛ inches, top to be in one piece, bottom in one piece, double seamed with the edges turned to sides, side made in one piece with edges turned, double seam, No. 8 wire used on wired edge of box, all other wired edges made of No. 10 wire, four 5-lb. rivets in handle, all other rivets to be 3-lb. In this box can be placed the tools required on a locomotive.

Third: Upon arrival of engine at terminal the tool box and loose tools about the engine, such as jacks, brooms and lanterns should be removed and taken to the storage building for necessary check and ascertaining if the full equipment required is intact. The first important feature for a systematic check on engine supplies is to see that the engineer is fully equipped with necessary tools and supplies as prescribed by the rules of the Operating Department, a complete individual record made, showing the date supplied, so that ready reference may be obtained at any time. This individual record should show, at all times, all tools and supplies excepting oils, waste and fuel furnished the engineman, the date supplied, why necessary, whether account loss, breakage or worn out. If on account of the latter two named causes, the worn out or broken tool must be returned in exchange and the records show accordingly. If the tool is lost, the tool checker must make prompt report through the channel desired to reach the official under whose supervision the engineman comes, so that proper discipline can be exercised. The tool checker should be advised through the proper channel the action taken in the premises to enable him to make record. In addition to keeping this individual record, a monthly report should be made to all the officials concerned, showing the name of the persons receiving any tools during the current month, the date supplied, the value and why necessary, and whether or not the old tool was returned in exchange. Such reports, issued monthly, should assist much in bringing about the maximum saving in this item of operating expense. Make this tool and supply question a personal affair between the company and employee.

Fourth: One of the most important necessities in having a systematic check on engine tools and supplies is a competent, determined, thoroughly reliable tool checker. Such a man should be well paid, and have full authority in order to bring about economical results. A person qualified, looking after this item of expense, will fully reimburse the railroad by the saving he will be enabled to attain. These tool checkers should be furnished with the necessary assistance for removing the tools and supplies from the engine upon arrival at terminal and the return of same to the engineman when he is ready for the next trip over the division. The duties of the tool checker should be to check the tools after they are brought to the storage building, see that they are properly placed in storage and that the full equipment be returned to the engineman when he is ready for the next trip—tool checkers to personally keep the individual record.

In conjunction with this system of checking supplies issued with a view of having an accurate and honest record made, it is very necessary that your oil house man be efficient and trustworthy.

To summarize: First, have a thoroughly organized and efficient corps of reliable tool checkers and oil house men.

Second: Inaugurate systematic schedules, records and reports and follow them up continually, locating careless employees.

Third: Insist upon having each engineman or conductor keep a full complement of tools as prescribed by the rules of the company, holding them responsible for neglect to do so at any time.

The procedure outlined above, if adopted, should result advantageously and bring about the economical uses of tools and supplies.

QUALIFICATIONS AND DUTIES OF THE TRAVELING ENGINEER.*

By W. L. Kellogg.

The traveling engineer must have knowledge and the faculty of imparting it. He must have convictions and courage to prosecute them. He must have no friends, and need have but few foes. He must be energetic and still maintain a couple of suits of overclothes. He must in all cases be able and willing to set the example of his precepts. He should learn early in his career that he is not employed to make excuses for men who were cut out for some other vocation besides railroading. He should be an expert, smooth and careful runner. He should be an authority on breakdowns and the mooted mysteries of the compound engine, the new valve gear and the setting of the old, the cause of brake failures and the way to prevent them. He must know the cost of materials and supplies and the best way to secure their economical use. He must be a fuel expert, a good judge of water and leave all opinions of other liquids to the politicians. In short, he should have few less requirements in his makeup than Carlton prescribes for an editor. So much for the man and a few of his multitudinous qualifications.

The instructions to the traveling engineer should be explicit, yet broad enough to meet all emergencies. He should be instructed to frame and guide sentiment, to look after and coach the firemen who are to make the future engineers. He should be instructed to look after the comfort of engineers and firemen on the road and at way terminals, so that a good and harmonious feeling will always be maintained. He should report meritorious conduct as well as the derelict and let the higher official take due action in rewarding proficiency, as well as punishing culpability thus reported.

To attempt to standardize his duties would in our estimation be a mistake. He should be considered as an assistant to the head that appoints him, which head usually knows its own weaknesses, and the duties assigned should be such as the next higher in authority cannot from lack of training or inclination properly attend to, and in this way balance the strength of the organization. There should, however, be some assigned duties. There is no more logic in allowing a traveling engineer to work at random than any other official or semi-official, yet he should not be so tied down that he has no opportunity to display his own peculiar abilities. The keynote of the answer will be found in the question itself if you will underscore the words "make himself." We are all what we make ourselves, not what others make us, and to a man given the range and latitude that usually falls to a traveling engineer the opportunity to make himself is always present.

As tutor and disciplinarian of engineers he should remember that we were all born innocent and have to learn; that to make a man is a great credit, to break one can only be justified as a painful duty. He should bear with the plodding yet safe man, yet remember it is an equal charity to rid the service of a dan-

* From an address before the Detroit Convention of the Traveling Engineers' Association.

gerous one. As an inspector of equipment and work he should early learn that which any official should know, namely, he cannot do it all himself, and his value will depend on his ability to command the co-operation of enginemen in seeing and reporting the defects that he would see if he were always there, and their insisting on the work being done for them as he would insist on it being done for him.

His mechanical training should have taught him the value of lubrication as an aid in the application of power and he should draw a close parallel between power as concerns energy and power as concerns authority. Nothing moves without applied power. Well lubricated machines or bodies move with minimum resistance. Friction in the machinery or friction among the men is often the result of power misapplied. An additional notch in the quadrant will force more steam through the cylinders and sometimes get you over the hill, just as you can force a man to do an unpleasant duty, but in an indifferent manner. If a few additional drops of oil through the lubricator or a few pleasantly spoken words will accomplish the same results you will have saved coal and machinery or the good will of a man, and the "esprit de corps" is the cream of an organization.

The science of railroading is the art of making things go smoothly, economically and on time. Nothing succeeds at haphazard. Select a man who is qualified to perform the peculiar duties that the service may stand in need of; assign him work that will take a reasonable percentage of his time to accomplish; systematize this portion of his work, but leave him some opportunity to develop along his own lines; vest him with all the authority needed; require brief yet complete reports of his work; insist on absolute loyalty to the company, but do not require him to be a "special agent."

Officials would do well to send their traveling engineers out occasionally on other lines to make observations, and if one is unable to absorb some good ideas from the poorest managed piece of railroad in the world, he is incompetent. Not one of us must get the idea that our road is perfect, or even the best, and the best will never be good enough. We must gather it in by observation, talking, arguing and reading a portion at least of the great mass of available knowledge as published by our mechanical papers.

A traveling engineer should make tests and be able at all times to give an intelligent reply to his superior on mechanical appliances such as injectors, lubricators, pops, brakes, etc.; also on materials, brasses, white metal, jacket iron and brake shoes. He should be able to furnish data and make intelligent argument in favor of, or against, engines, cars, wrecking appliances and the various component parts when his company is in the market for such equipment or parts. He should be called in consultation and be able to suggest the necessary changes from his notebook to make each time card a better time card. He should be an assistant, not a "knocker." If he spends his time telling what he would do were he master mechanic or superintendent of motive power, the chances are he will never be able to reach the point where a demonstration will be possible, although if his selection was made on merit and his ambition rightly directed there is no reason why he should not obtain one of these positions.

The traveling engineer should be in comparison like a huge sponge, able to absorb all he comes in contact with. If he cannot learn from the humblest wiper or truck builder, or the various classes with whom he has to deal he has mistaken his calling. These items of detail he must gather and segregate and compare until he is able to say this or that is the best method of practice. The traveling enginer should make indicator, fuel and other tests and report to the master mechanic, who usually accepts them without verification. He must be a close observer and take a live interest in economy; be an organizer, keep his men happy and properly keyed up to the requirements. He should be a believer in recognition as well as reward for good service rendered.

Let us dwell for a moment on the necessity of mental labor by our younger employees which must be stimulated and rightly directed. We often find young men willing workers in physical lines who are mentally paralyzed and who never read of the exploits, experiments and perplexing problems which have been worked out by past generations, the results of which should be in his library and much of it in his mind. The traveling engineer has the opportunity to enforce this mental culture.

The traveling engineer should take up the matter of waste—unnecessary popping, engines blowing and all things in general, and be able to illustrate its cost in the aggregate. The traveling engineer, above all other things, should preach and talk caution. His motto should be: "Better behind time at a terminal than ahead of time into eternity." These are days of high speed, probably in all walks of life. It is both expensive and dangerous. Much has been said and written along the above lines and the handling of locomotives drawing our friends and families, but the greatest advancement must come through the medium of that personal interest that every engineman and officer must have if he is desirous of increasing his ability and sphere of usefulness. If men are not thus inclined, they should be weeded out early in the game. Some few men have less judgment than the ordinary cow. You will know them because their chief interest centers on reaching terminals and pay day. If the traveling engineer finds them and weeds them out, he will have at least accomplished the much desired end of having a good personnel.

MALLEABLE IRON—PHYSICAL CHARACTERISTICS.

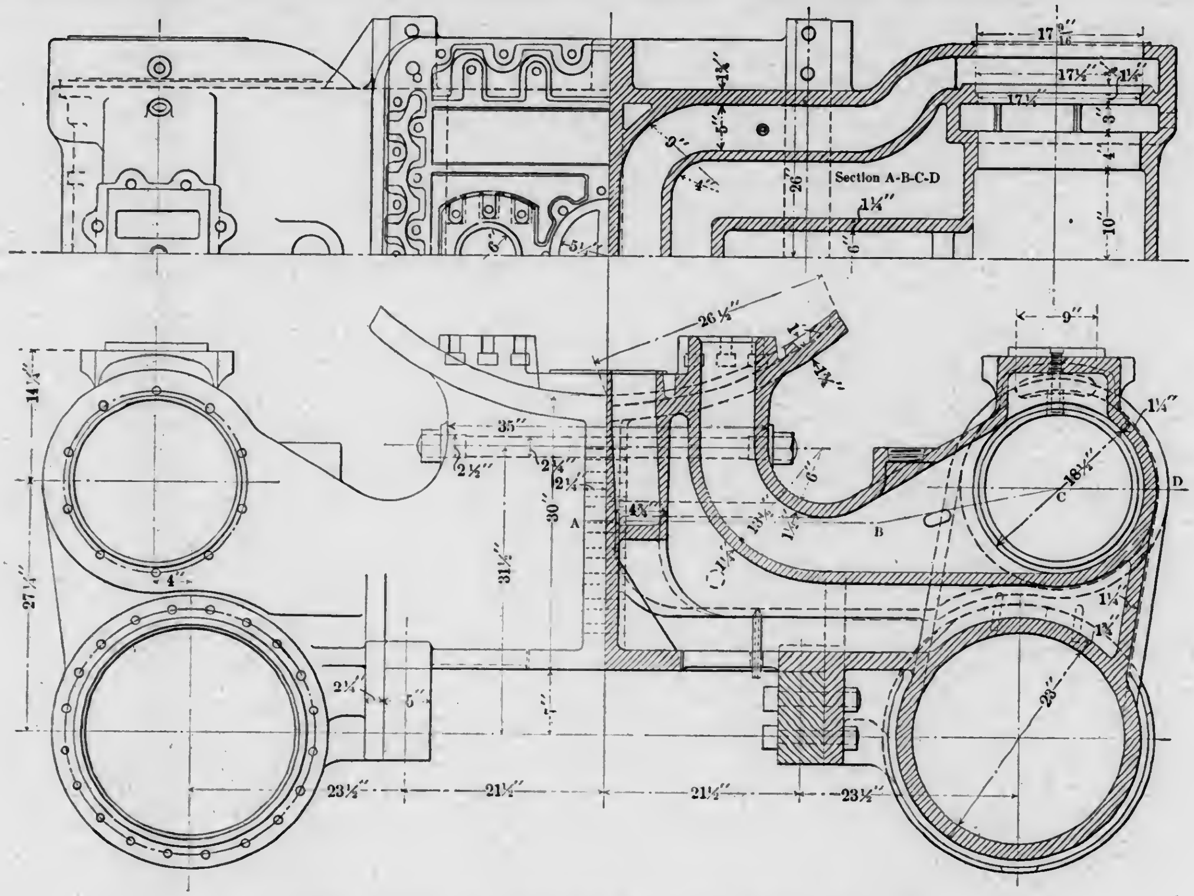
The physical characteristic that gives malleable iron its greatest value, and wherein it differs from gray iron, lies in its ability to resist shocks and an increased tensile strength. The degree of malleability in light and heavy castings varies. In a light casting ¼ in. thick and less, it means a soft, pliable condition and the ability to withstand considerable distortion without fracture, while in the heavy sections, ½ in. and over, it means the ability to resist shocks without bending or breaking.

The tensile strength of malleable iron varies with the thickness of the metal, the lighter sections having a greater strength per square inch than the heavier sections. This fact is now being recognized by engineers and at least one Eastern railroad, which requires its malleable castings made in accordance with specifications, designates the tensile strength desired in its castings to be as follows: Sections ⅜ in. thick or less should have a tensile strength of not less than 40,000 lb. per square inch; those of ⅜ to ¾ in. thick, not less than 38,000 lbs. per square inch, and those over ¾ in. not less than 36,000 lbs. per square inch. In recent tests along these lines, test bars ⅝ and ⅞ in. diameter were made in the same mold and poured from the same ladle, thus insuring equality of metal, and annealed together. The average tensile strength of five pairs of bars so treated, representing five heats, was: ⅝ in. bars, 45,095 lbs. per square inch; ⅞ in. bars, 41,316 lbs. per square inch. Average elongation in 6 in.: ⅝ in. bars, 5 3/10 per cent.; ⅞ in. bars, 4 2/10 per cent.

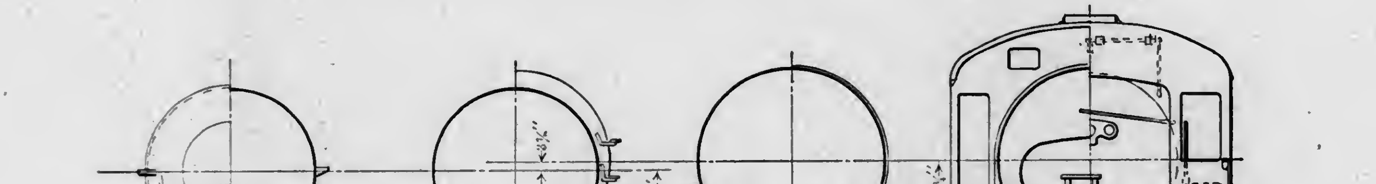
A very high tensile strength can be obtained approaching that of cast steel, but at the expense of the malleability of the product. The writer has seen malleable test bars having a tensile strength of between 60,000 and 70,000 lbs. per square inch, but the ductility and ability to resist shocks of these bars were not equal to that of bars breaking at 40,000 to 45,000 lbs. per square inch.

It was formerly the general belief that the strength of malleable iron was largely in the white skin always found on this material, but it has frequently been demonstrated that the removal of the skin does not proportionately lessen the strength of the casting.—*C. H. Gale, before the Pittsburgh Foundrymen's Association.*

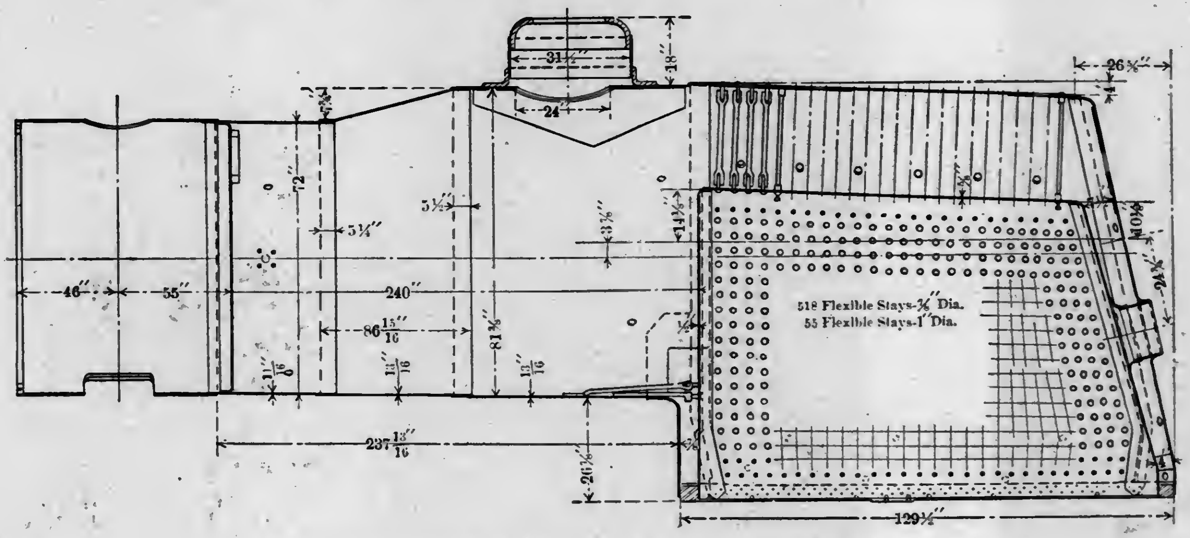
It is safe to say that more than $80,000,000 has been expended upon railroad shops and their equivalent within the last ten years.—*George A. Damon.*



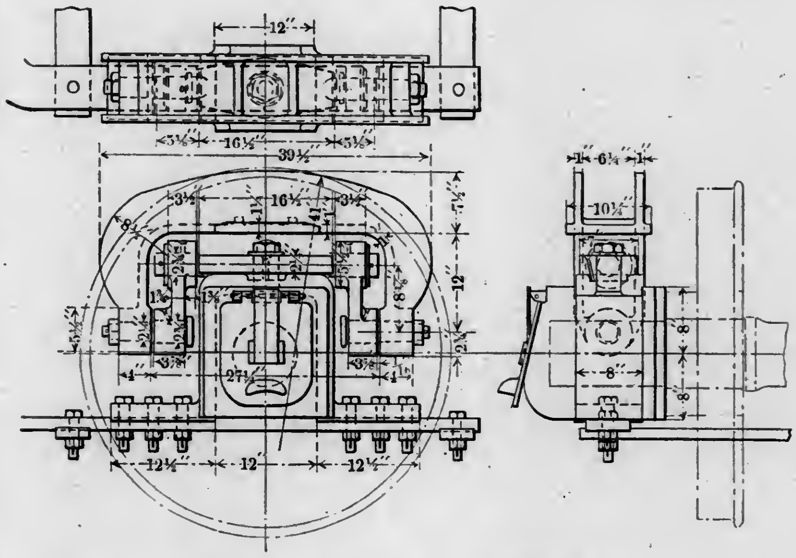
CYLINDERS—PACIFIC TYPE LOCOMOTIVE—CHICAGO AND ALTON RAILROAD.



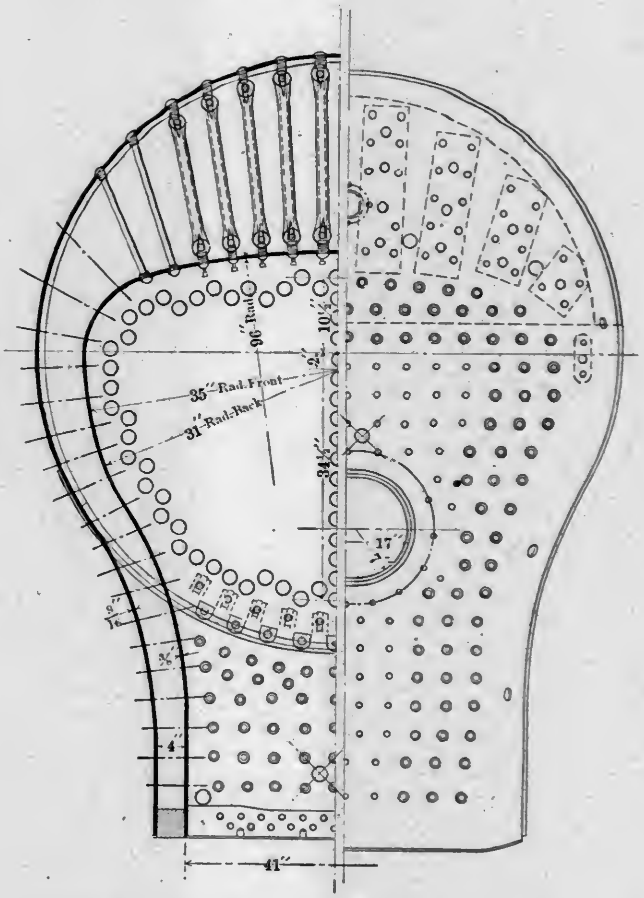
GENERAL ELEVATION AND SECTIONS OF PACIFIC TYPE LOCOMOTIVE—CHICAGO AND ALTON RAILROAD.



LONGITUDINAL SECTION OF BOILER—C. & A. PACIFIC TYPE LOCOMOTIVE.



TRAILING TRUCK—C. & A. LOCOMOTIVE.



SECTION THROUGH FIREBOX AND END ELEVATION.

PACIFIC TYPE LOCOMOTIVE WITH NARROW FIRE BOX.

CHICAGO & ALTON RAILROAD.

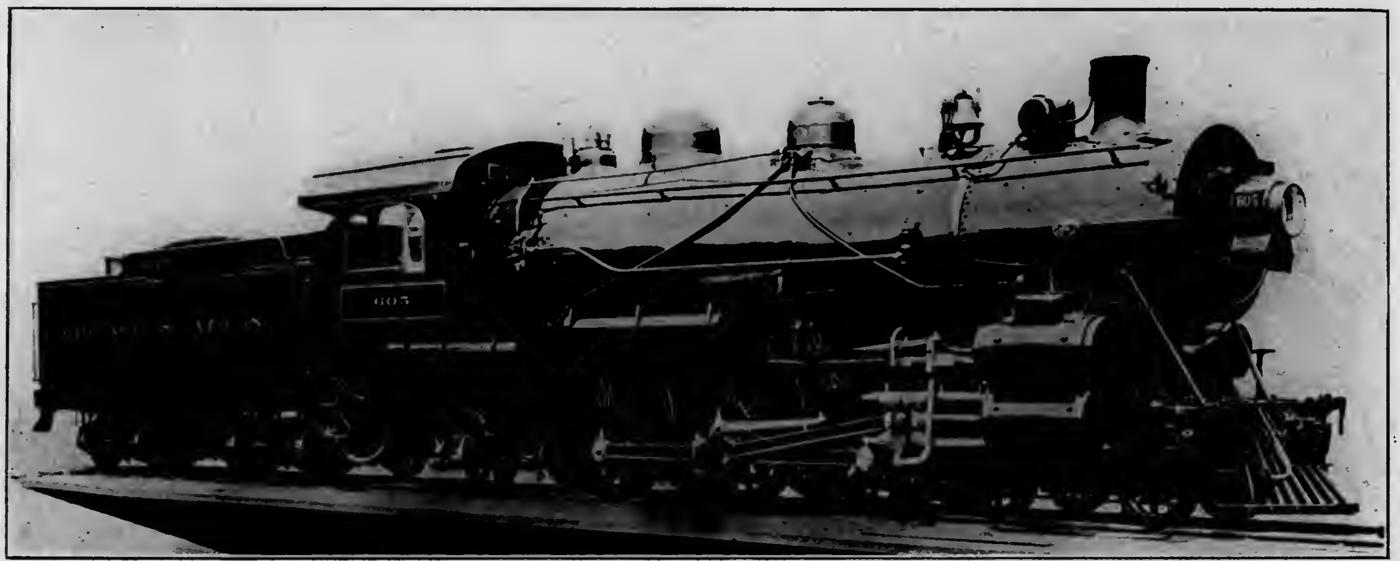
The first standard gauge Pacific type locomotives built by the Baldwin Locomotive Works were delivered early in 1903 to the Chicago & Alton Railroad. There were two engines in this order having driving wheels respectively 73 and 80 in. in diameter. (AMERICAN ENGINEER, March, 1903, page 85,) These locomotives weigh 219,000 lbs. total, have 22 x 28 in. cylinders and were at that time the largest passenger locomotives in the world. In the following year three more engines of the same type were delivered by the same company, which had a total weight of 221,550 lbs. and were again the record holders for size of passenger locomotives. (See AMERICAN ENGINEER, April, 1904, page 133.)

This company has recently received five more Pacific type locomotives from the same works, which, while they are somewhat larger than the earlier ones, do not differ from them in any essential features except the use of the Walschaert valve gear and wagon top boilers with narrow fire boxes. The return to the narrow fire box is the most noticeable feature of the design and follows some experiments which have been made with a similar form of fire box on some Atlantic type locomotives built about two years ago.

The accompanying table will permit a comparison of the general features and important ratios of these locomotives with four other heavy Pacific type engines. The narrow fire box, of course, throws the ratios concerned with it entirely beyond the limits which have been considered proper for this type of engine; in other respects, however, the design is normal.

Road	N. Y. C.	C. & A.	Erie	N. Y. N. H. & H.	C. B. & Q.
Tractive effort	29,200	34,500	30 300	31,560	31,100
Total weight	266,000	243,200	230,500	229 500	228,000
Weight on drivers	171,500	146,500	149,000	142,500	150,000
Heating surface	4209.9	3927	3326.	3947.4	3932.
Grate area	56.5	33.	56.5	53.5	54.
B. D. factor	550.	640.	699.	585.	585.
Heat. surf. ÷ grate area	74.5	119.	58.7	73.5	71.3
Grate area ÷ vol. cyls	4.58	2.44	4.7	4.2	4.39
Heat. surf. ÷ vol. cyls	34[illegible].	290.	277.	321.	318.
Ref. in AMER. ENGR	1908 p. 164	....	1905 p. 172	1907 p. 431	1906 p. 300

The boiler is of the wagon top type, with a narrow fire box, and has the largest ratio (119) of heating surface to grate area



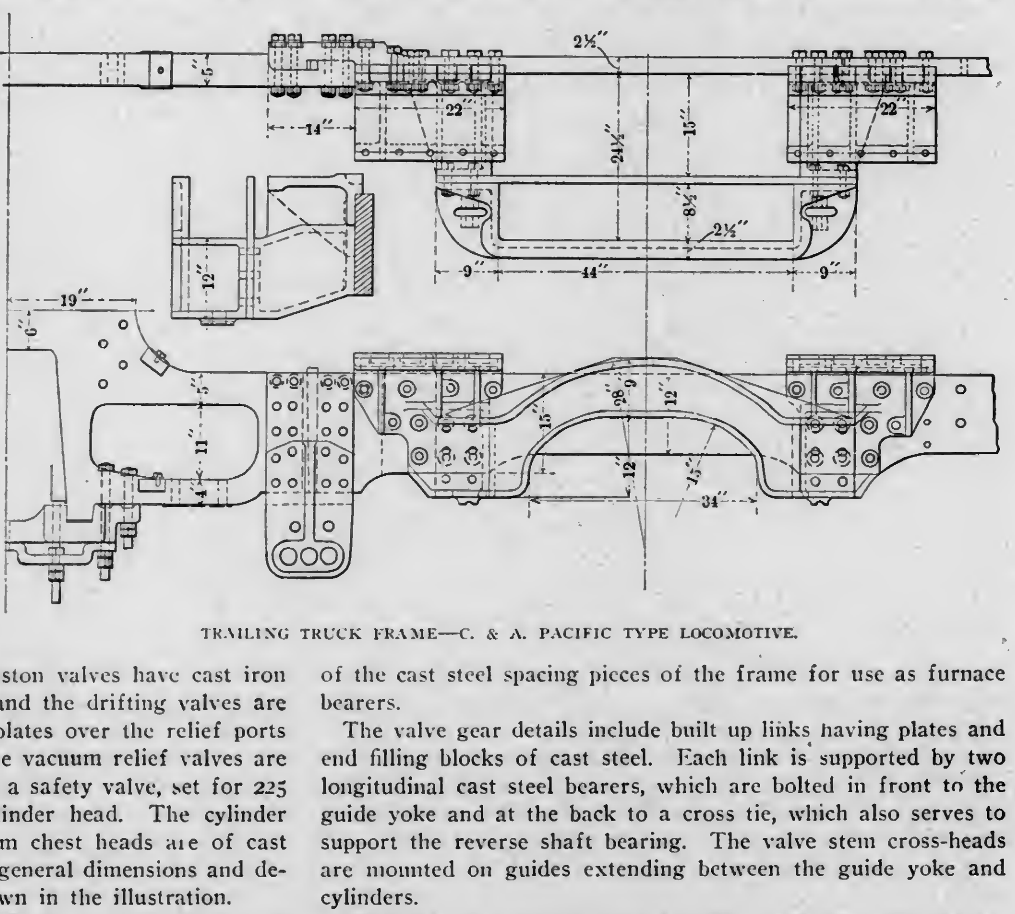
PACIFIC TYPE LOCOMOTIVE WITH NARROW FIREBOX—CHICAGO AND ALTON RAILROAD.

of any locomotive on our records. It has a diameter of 72 in. at the front end, which is enlarged to 83 in. at the dome ring. The grate is horizontal and is rocked in three sections. The dump grate is located at the back end. The fire box has a sloping back head and roof sheet and is radially stayed. The front end of the crown is supported by three rows of sling stays and there are 573 flexible staybolts disposed in the sides, back and throat. The crown and side sheets of both the inside and outside fire boxes are in one piece. Since almost the entire fire box is placed back of the driving wheels large radii could be used in the curvature of the side water legs, which condition has evidently been taken advantage of, as is shown in the section of the fire box. The front end is of the self-clearing type and is equipped with a high single exhaust nozzle and double petticoat pipe. The adjustable diaphragm plate is located in front of the nozzle. The boiler is liberally supplied with means for washing out, there being five blow-off cocks, two in the waist, one in each water leg and one in the throat. Numerous washout plugs are provided, located as shown in the illustration.

The cylinders are 23 in. in diameter by 28 in. stroke and have 16 in. piston valves. They are cast integral with the saddle in the usual manner and the two castings have in addition to the double row of bolts through the flanges, two heavy tie bolts, $2\frac{1}{4}$ in. in diameter, which pass through the saddle, as is shown in the illustration. The extreme width over the assembled cylinder castings is 10 ft. 2 in. The piston valves have cast iron bodies with L-shaped packing rings and the drifting valves are of the Pennsylvania style, with flat plates over the relief ports in the top of the valve chamber. The vacuum relief valves are placed in the live steam passages and a safety valve, set for 225 lbs. pressure, is located on each cylinder head. The cylinder heads are of cast steel, but the steam chest heads are of cast iron. The arrangement of ports and general dimensions and design of these cylinders is clearly shown in the illustration.

The frames are in two parts, the main frames extending from the front bumper, below the cylinders, to a splice just back of the third driving box pedestal, from which point they are continued with a slab form of trailing frame. The main frames are 5 in. wide, of forged iron and have a section, 5 x 10 in., at their connection to the cylinders. The trailing frames are $2\frac{1}{2}$ in. wide. The pedestal binders are of cast steel and are lugged and bolted to the pedestals. Substantial frame bracing is provided, consisting, in addition to the cast steel foot plate at each end, of bracing of the same material placed just back of the cylinders, between the first and second pair of driving wheels, above the main driving pedestals and in front of the fire box.

The arrangement of the trailing truck, which has outside boxes and a supplementary frame bolted to the trailing frame, is clearly shown in the illustrations and requires no comment. The trailing truck is of the Rushton radial type and advantage is taken



TRAILING TRUCK FRAME—C. & A. PACIFIC TYPE LOCOMOTIVE.

of the cast steel spacing pieces of the frame for use as furnace bearers.

The valve gear details include built up links having plates and end filling blocks of cast steel. Each link is supported by two longitudinal cast steel bearers, which are bolted in front to the guide yoke and at the back to a cross tie, which also serves to support the reverse shaft bearing. The valve stem cross-heads are mounted on guides extending between the guide yoke and cylinders.

The tender is constructed in accordance with the railroad company's standard, the frame being built up of 13 in. channels and is carried on arch bar trucks with cast steel bolsters. The dimensions, weights and ratios of the locomotives are as follows:

GENERAL DATA.

Gauge	4 ft. 8½ in.
Service	Passenger
Fuel	Bit. Coal
Tractive effort	34,500 lbs.
Weight in working order	243,200 lbs.
Weight on drivers	146,500 lbs.
Weight on leading truck	47,600 lbs.
Weight on trailing truck	49,100 lbs.
Weight of engine and tender in working order	405,000 lbs.
Wheel base, driving	13 ft. 9 in.
Wheel base, total	32 ft. 8 in.
Wheel base, engine and tender	65 ft. 8½ in.

RATIOS.

Weight on drivers ÷ tractive effort	4.26
Total weight ÷ tractive effort	7.05
Tractive effort × diam. drivers ÷ heating surface	640.00
Total heating surface ÷ grate area	119.00
Firebox heating surface ÷ total heating surface, per cent	5.24
Weight on drivers ÷ total heating surface	37.30
Total weight ÷ total heating surface	62.00
Volume both cylinders, cu. ft	13.50
Total heating surface ÷ vol. cylinders	290.00
Grate area ÷ vol. cylinders	2.44

CYLINDERS.

Kind	Simple
Diameter and stroke	23 × 28 in.

VALVES.

Kind	Piston
Diameter	16 in.
Greatest travel	6 in.
Lead, constant	¼ in.

WHEELS.

Driving, diameter over tires	73 in.
Driving, thickness of tires	3½ in.
Driving journals, main, diameter and length	10½ × 12 in.
Driving journals, others, diameter and length	9 × 12 in.
Engine truck wheels, diameter	33 in.
Engine truck, journals	6½ × 12¼ in.
Trailing truck wheels, diameter	42 in.
Trailing truck, journals	8 × 14 in.

BOILER.

Style	W. T.
Working pressure	200 lbs.
Outside diameter of first ring	72 in.
Firebox, length and width	120⅛ × 40¼ in.
Firebox, water space	F., 4½—S. and B., 4 in.
Tubes, number and outside diameter	357—2 in.
Tubes, length	20 ft.
Heating surface, tubes	3,721 sq. ft.
Heating surface, firebox	206 sq. ft.
Heating surface, total	3,927 sq. ft.
Grate area	33 sq. ft.

TENDER.

Tank	Waterbottom
Frame	13 in. channels
Wheels, diameter	36 in.
Water capacity	9,250 gals.
Coal capacity	12½ tons

FORCED LUBRICATION FOR AXLE-BOXES.*

This paper describes a system of forced lubrication as arranged for the driving axle-boxes of some of the steam-cars (motor) of the Taff Vale Railway Company.† Before entering into a detailed description of the system used, it will perhaps be advisable to give a few of the more necessary particulars concerning these cars.

The engine is carried on a four-wheeled truck of 9 feet 6 inches wheel base and 2 feet 10 inches diameter wheels, the boiler (of double-ended locomotive type, lying transversely across the frame) being placed immediately over the center of the leading or driving-axle. The front end of the coach is supported by means of a bogie center, carried between the frames at a distance of 4 feet from the trailing-axle, or 5 feet 6 inches from the leading-axle. When the car is loaded with its full complement of passengers, the weight on the driving-axle is 15 tons 13 cwts., the weight at the rail being 17 tons 6 cwts. The journals are 6 inches diameter by 9½ inches length; therefore the pressure, being two-thirds of the projected area of the brass as bearing area, is 466 lbs. per square inch, the number of the revolutions of the journal, at a speed of 30 miles per hour, being practically 300. With this pressure and high rubbing velocity an undue amount of oil was being used with the ordinary method of lubrication, while cases of the bearings running hot were not infrequent, therefore the following arrangement for lubricating the journals under pressure was adopted.

To a cross-stay in front of the driving-axle, a small gun-metal tank of rectangular section is fixed. On the side of this tank, near the driving-axle and in connection with the tank, two small rotary pumps—right- and left-handed—are fitted, the one for forward running and the other for backward running. These pumps are driven directly from the driving-axle by means of a belt passing over a flanged pulley carried midway between the pumps, the pulley containing on each side of it a roller-clutch, somewhat similar to a free-wheel arrangement, fixed to the driving-spindle of the pumps. By these means, the one belt drives either pump forward or backward, the other pump being free.

Following the process through, for the lubrication of one of the journals, when the car is in motion, oil is pumped from the tank and forced through a coiled copper pipe to the top of the axle-box. An oil channel 8¼ inches long, 9/16 inch deep, is cut in the crown of the box, leaving a margin of metal at each side of the channel of ⅜ inch flat, which is found, when the box is properly bedded to the journal, to be quite sufficient to ensure that it shall be perfectly oil-tight at the pressures attained.

After passing round the journal, the oil is collected in the axle-box cellar, and from there is brought back to the tank by means of a flexible pipe which allows for the rise and fall of the axle-box, care being taken that the reservoir into which the oil is returned sufficiently below the cellar to drain it. At each side of the axle-box cellar a half ring is fitted with bearing area about ⅜ inch wide. These half-rings are bedded well to the axles, and are supported upon a couple of small coil springs which holds the rings up to the journal with a fair pressure, and so prevent the escape of oil along the journal on the bottom side. The supply tank is so arranged that the return oil, after draining from the cellar into it, shall pass through a filter before being again sent through the pump. Such briefly is a general description of the method adopted.

Many points arise, however, in regard to the working of the arrangement which it will be well to explain. In the first place, the pumps when running fast (at a speed of 30 miles per hour, the revolutions of the pump are 440 per minute) deal with a greater quantity of oil than can be accommodated in the circuit at a pressure of, say, 20 lbs. per square inch, above which, in practice, it has not been found advisable to work. A relief valve is therefore fitted to each pump with an adjustable spring which enables the pressure at which each pump shall work to be regulated. The excess oil, when pumping, simply passes back into the tank again, through the relief valve against the pressure of the spring. A small pressure-gauge connected to each pump, and fixed in the driver's cab, shows the pressure of the oil pumped on both forward and backward running, whilst also acting as an indicator should failure of either pump occur at any time. Should this happen from any cause, the ordinary system of lubrication, by means of a lubricating-box in the cab, is at hand. This lubricating-box is also necessary, to enable oil to be put into the axle-boxes after the car has been standing for a day or two, and so avoid starting away with dry axle-boxes.

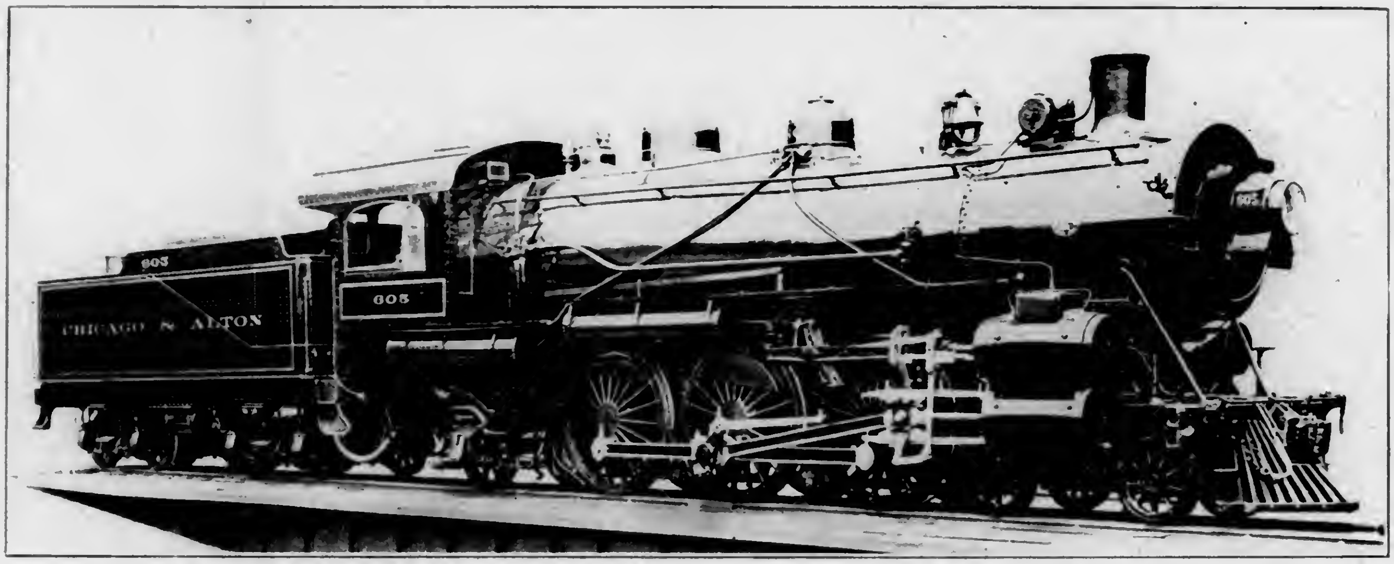
To prevent the oil from the running pump flowing into the other pump and causing it to run backwards, a small ball-valve is placed in the three-way piece leading from each pump to the circuit. The movement of the axle-boxes relatively to the tank and pumps was met in the first instance by trying different sorts of flexible piping, but finally, ordinary coiled copper piping was adopted, both on account of its comparative durability and of its accessibility at any time.

The belt drive for the pumps at once gives a simple method of driving and one which allows for a small relative motion of the axle and pulley. It is apt, however, to soon become saturated with oil and then slipping occurs. An occasional application of one of the various belting mixtures, however, greatly reduces this slipping. When equal relief-valve springs were put in, it was noticed that the pressure indicated for forward and backward running varied considerably, probably due to the difference in the slip of the belt in each case. The filters in the tank are removable, and are taken out and cleaned at the end of each day's work, the oil being first drawn off through the stop-plug, the thicker part of the oil, after straining, being then replaced by a small supply of fresh oil.

The foregoing description shows one method of dealing with an every-day problem in connection with the running of railway motor-cars, or any rolling stock in which the pressure on the

* Paper presented before the Institute of Mechanical Engineers, July, 1908, Meeting, by T. Hurry Riches and Bertie Reynolds.

† See AMERICAN ENGINEER, April, 1907, p. 134.



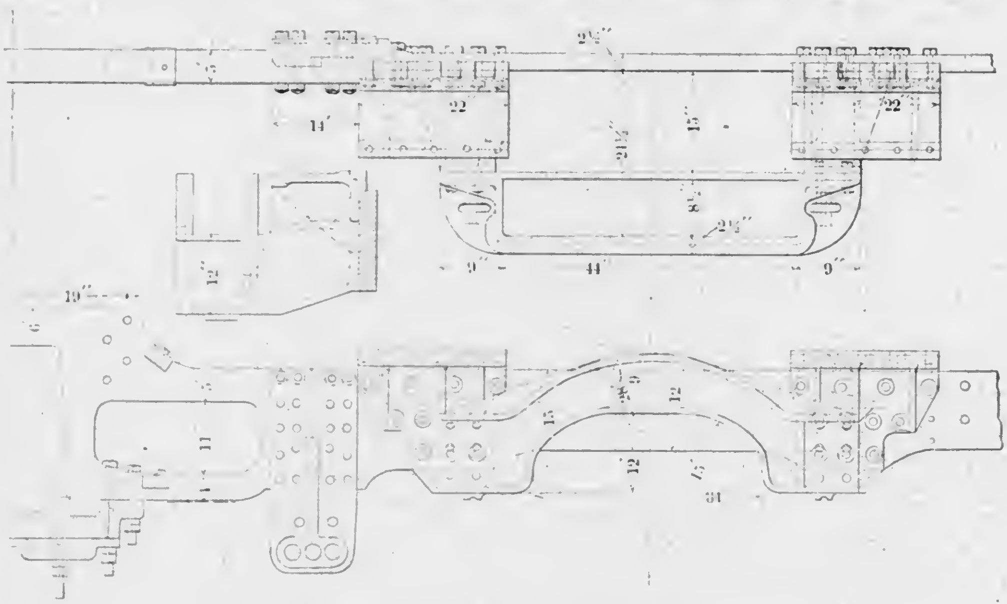
PACIFIC TYPE LOCOMOTIVE WITH NARROW FIREBOX—CHICAGO AND ALTON RAILROAD.

of any locomotive on our records. It has a diameter of 72 in. at the front end, which is enlarged to 83 in. at the dome ring. The grate is horizontal and is rocked in three sections. The dump grate is located at the back end. The fire box has a sloping back head and roof sheet and is radially stayed. The front end of the crown is supported by three rows of sling stays and there are 573 flexible staybolts disposed in the sides, back and throat. The crown and side sheets of both the inside and outside fire boxes are in one piece. Since almost the entire fire box is placed back of the driving wheels large radii could be used in the curvature of the side water legs, which condition has evidently been taken advantage of, as is shown in the section of the fire box. The front end is of the self clearing type and is equipped with a high single exhaust nozzle and double petticoat pipe. The adjustable diaphragm plate is located in front of the nozzle. The boiler is liberally supplied with means for washing out, there being five blow-off cocks, two in the waist, one in each water leg and one in the throat. Numerous washout plugs are provided, located as shown in the illustration.

The cylinders are 23 in. in diameter by 28 in. stroke and have 16 in. piston valves. They are cast integral with the saddle in the usual manner and the two castings have in addition to the double row of bolts through the flanges, two heavy tie bolts, 2 [illegible] in. in diameter, which pass through the saddle, as is shown in the illustration. The extreme width over the assembled cylinder castings is 10 ft. 2 in. The piston valves have cast iron bodies with L shaped packing rings and the drifting valves are of the Pennsylvania style, with flat plates over the relief ports on the top of the valve chamber. The vacuum relief valves are placed in the live steam passages and a safety valve, set for 225 lbs. pressure, is located on each cylinder head. The cylinder heads are of cast steel, but the steam chest heads are of cast iron. The arrangement of ports and general dimensions and design of these cylinders is clearly shown in the illustration.

The frames are in two parts, the main frames extending from the front bumper, below the cylinders, to a splice just back of the third driving box pedestal, from which point they are continued with a slab form of trailing frame. The main frames are 5 in. wide, of forged iron and have a section, 5 x 10 in., at their connection to the cylinders. The trailing frames are 2½ in. wide. The pedestal binders are of cast steel and are lugged and bolted to the pedestals. Substantial frame bracing is provided, consisting, in addition to the cast steel foot plate at each end, of bracing of the same material placed just back of the cylinders, between the first and second pair of driving wheels, above the main driving pedestals and in front of the fire box.

The arrangement of the trailing truck, which has outside boxes and a supplementary frame bolted to the trailing frame, is clearly shown in the illustrations and requires no comment. The trailing truck is of the Rushton radial type and advantage is taken



TRAILING TRUCK FRAME—C. & A. PACIFIC TYPE LOCOMOTIVE.

of the cast steel spacing pieces of the frame for use as furnace bearers.

The valve gear details include built up links having plates and end filling blocks of cast steel. Each link is supported by two longitudinal cast steel bearers, which are bolted in front to the guide yoke and at the back to a cross tie, which also serves to support the reverse shaft bearing. The valve stem cross-heads are mounted on guides extending between the guide yoke and cylinders.

The tender is constructed in accordance with the railroad company's standard, the frame being built up of 13 in. channels and is carried on arch bar trucks with cast steel bolsters. The dimensions, weights and ratios of the locomotives are as follows:

GENERAL DATA.

Gauge	4 ft. 8½ in.
Service	Passenger
Fuel	Bit. Coal
Tractive effort	31,500 lbs.
Weight in working order	213,200 lbs.
Weight on drivers	146,500 lbs.
Weight on leading truck	17,600 lbs.
Weight on trailing truck	49,100 lbs.
Weight of engine and tender in working order	405,000 lbs.
Wheel base, driving	13 ft. 9 in.
Wheel base, total	32 ft. 8 in.
Wheel base, engine and tender	65 ft. 8½ in.

RATIOS.

Weight on drivers ÷ tractive effort	4.26
Total weight ÷ tractive effort	7.05
Tractive effort × diam. drivers ÷ heating surface	649.00
Total heating surface ÷ grate area	119.00
Firebox heating surface ÷ total heating surface, per cent	5.24
Weight on drivers ÷ total heating surface	37.30
Total weight ÷ total heating surface	62.00
Volume both cylinders, cu. ft	13.50
Total heating surface ÷ vol. cylinders	290.00
Grate area ÷ vol. cylinders	2.44

CYLINDERS.

Kind	Simple
Diameter and stroke	23 × 28 in.

VALVES.

Kind	Piston
Diameter	16 in.
Greatest travel	6 in.
Lead, constant	¼ in.

WHEELS.

Driving, diameter over tires	73 in.
Driving, thickness of tires	3½ in.
Driving journals, main, diameter and length	10½ × 12 in.
Driving journals, others, diameter and length	9 × 12 in.
Engine truck wheels, diameter	33 in.
Engine truck, journals	6½ × 12½ in.
Trailing truck wheels, diameter	42 in.
Trailing truck, journals	8 × 11 in.

BOILER.

Style	W. T.
Working pressure	200 lbs.
Outside diameter of first ring	72 in.
Firebox, length and width	120⅛ × 40¾ in.
Firebox, water space	F., 1½—S. and B., 4 in.
Tubes, number and outside diameter	357—2 in.
Tubes, length	20 ft.
Heating surface, tubes	3,721 sq. ft.
Heating surface, firebox	206 sq. ft.
Heating surface, total	3,927 sq. ft.
Grate area	33 sq. ft.

TENDER.

Tank	Waterbottom
Frame	13 in. channels
Wheels, diameter	36 in.
Water capacity	9,250 gals.
Coal capacity	12½ tons

FORCED LUBRICATION FOR AXLE-BOXES.*

This paper describes a system of forced lubrication as arranged for the driving axle-boxes of some of the steam-cars (motor) of the Taff Vale Railway Company.† Before entering into a detailed description of the system used, it will perhaps be advisable to give a few of the more necessary particulars concerning these cars.

The engine is carried on a four-wheeled truck of 9 feet 6 inches wheel base and 2 feet 10 inches diameter wheels, the boiler (of double-ended locomotive type, lying transversely across the frame) being placed immediately over the center of the leading or driving-axle. The front end of the coach is supported by means of a bogie center, carried between the frames at a distance of 4 feet from the trailing-axle, or 5 feet 6 inches from the leading-axle. When the car is loaded with its full complement of passengers, the weight on the driving-axle is 15 tons 13 cwts., the weight at the rail being 17 tons 6 cwts. The journals are 6 inches diameter by 9½ inches length; therefore the pressure, being two-thirds of the projected area of the brass as bearing area, is 466 lbs. per square inch, the number of the revolutions of the journal, at a speed of 30 miles per hour, being practically 300. With this pressure and high rubbing velocity an undue amount of oil was being used with the ordinary method of lubrication, while cases of the bearings running hot were not infrequent, therefore the following arrangement for lubricating the journals under pressure was adopted.

To a cross stay in front of the driving-axle, a small gun-metal tank of rectangular section is fixed. On the side of this tank, near the driving-axle and in connection with the tank, two small rotary pumps—right- and left-handed—are fitted, the one for forward running and the other for backward running. These pumps are driven directly from the driving-axle by means of a belt passing over a flanged pulley carried midway between the pumps, the pulley containing on each side of it a roller-clutch, somewhat similar to a free-wheel arrangement, fixed to the driving-spindle of the pumps. By these means the one belt drives either pump forward or backward, the other pump being free.

Following the process through, for the lubrication of one of the journals, when the car is in motion, oil is pumped from the tank and forced through a coiled copper pipe to the top of the axle-box. An oil channel 8¼ inches long, 9/16 inch deep, is cut in the crown of the box, leaving a margin of metal at each side of the channel of ⅜ inch flat, which is found, when the box is properly bedded to the journal, to be quite sufficient to ensure that it shall be perfectly oil-tight at the pressures attained.

After passing round the journal, the oil is collected in the axle-box cellar, and from there is brought back to the tank by means of a flexible pipe which allows for the rise and fall of the axle-box, care being taken that the reservoir into which the oil is returned sufficiently below the cellar to drain it. At each side of the axle-box cellar a half ring is fitted with bearing area about ⅜ inch wide. These half-rings are bedded well to the axles, and are supported upon a couple of small coil springs which holds the rings up to the journal with a fair pressure, and so prevent the escape of oil along the journal on the bottom side. The supply tank is so arranged that the return oil, after draining from the cellar into it, shall pass through a filter before being again sent through the pump. Such briefly is a general description of the method adopted.

Many points arise, however, in regard to the working of the arrangement which it will be well to explain. In the first place, the pumps when running fast (at a speed of 30 miles per hour, the revolutions of the pump are 440 per minute) deal with a greater quantity of oil than can be accommodated in the circuit at a pressure of, say, 20 lbs. per square inch, above which, in practice, it has not been found advisable to work. A relief valve is therefore fitted to each pump with an adjustable spring which enables the pressure at which each pump shall work to be regulated. The excess oil, when pumping, simply passes back into the tank again, through the relief valve against the pressure of the spring. A small pressure-gauge connected to each pump, and fixed in the driver's cab, shows the pressure of the oil pumped on both forward and backward running, whilst also acting as an indicator should failure of either pump occur at any time. Should this happen from any cause, the ordinary system of lubrication, by means of a lubricating-box in the cab, is at hand. This lubricating-box is also necessary, to enable oil to be put into the axle-boxes after the car has been standing for a day or two, and so avoid starting away with dry axle-boxes.

To prevent the oil from the running pump flowing into the other pump and causing it to run backwards, a small ball valve is placed in the three-way piece leading from each pump to the circuit. The movement of the axle-boxes relatively to the tank and pumps was met in the first instance by trying different sorts of flexible piping, but finally, ordinary coiled copper piping was adopted, both on account of its comparative durability and of its accessibility at any time.

The belt drive for the pumps at once gives a simple method of driving and one which allows for a small relative motion of the axle and pulley. It is apt, however, to soon become saturated with oil and then slipping occurs. An occasional application of one of the various belting mixtures, however, greatly reduces this slipping. When equal relief-valve springs were put in, it was noticed that the pressure indicated for forward and backward running varied considerably, probably due to the difference in the slip of the belt in each case. The filters in the tank are removable, and are taken out and cleaned at the end of each day's work, the oil being first drawn off through the stop plug, the thicker part of the oil, after straining, being then replaced by a small supply of fresh oil.

The foregoing description shows one method of dealing with an every-day problem in connection with the running of railway motor-cars, or any rolling stock in which the pressure on the

* Paper presented before the Institute of Mechanical Engineers, July, 1908, Meeting, by T. Hurry Riches and Bertie Reynolds.

† See AMERICAN ENGINEER, April, 1907, p. 131.

STEEL CAR CONSTRUCTION AND MAINTENANCE

By G. E. Carson.

(Editor's Note: In the January issue of this year there appeared an extensive article on "Repairing Steel Cars on the Pittsburgh & Lake Erie Railroad." The following article, which is taken from a paper presented before the Railway Club of Pittsburgh, throws some additional light on this subject and also contains some interesting comments on steel car construction. Mr. Carson's experience with steel cars dates from the time they were introduced on the P. & L. E. R. R., and since this was one of the first roads to adopt them, he is entitled to speak with authority. At the time the article was prepared Mr. Carson was master car builder of the above-mentioned road, but has since been promoted to a similar position on the N. Y. C. & H. R. R. R.)

Construction.

All sheets should be free from waves and roughness, for paint only tends to exaggerate them, giving the car an unfinished appearance. All parts should be free from flash, grease and rust before painting. In all cases where metal is placed against metal the unexposed parts should be coated with a heavy paint mixture before they are riveted or concealed, so as to exclude moisture. During the process of construction a competent inspector should see that the riveting and bolting together of the parts are done in a substantial and workmanlike manner

In looking at the construction of steel cars I am often led to believe that the designer sometimes forgets the necessity of building a structure that can be repaired with economy and despatch. A few points, which from a repair shop view, should receive careful attention are as follows:

Corner posts on large hopper cars should be in two sections so that it will be unnecessary to remove the entire stake in order to make repairs to the lower portion which is damaged oftener than the top.

Few, if any, of the heavy capacity cars have a place of sufficient strength under which jacks can be placed to raise a loaded car, without damage to the car or endangering the lives of the workmen. All one hundred thousand pound capacity cars should have suitable places for jacking on each end of the car close to the body bolsters. The lighter capacity cars are usually not so defective in this respect.

I believe all center sills should be spliced in front of the body bolsters, as we well know that that portion of the sills between the body bolsters and end sills is most subject to damage; if spliced the damaged sections can be removed and repaired at less cost than where the sill is a continuous member.

Train lines should never be hung between the center sills, as they are inaccessible, either for making repairs or discovering leaky connections, and are therefore neglected by the ordinary inspector. When possible, it is preferable to have the train line and all parts of the air brake close to the outside of car, where leaks can be easily discovered and repairs quickly made.

All cars should be constructed so that it will be possible to apply a train chain to each body bolster in order to haul a defective car to the shop. There are thousands of cars now in service to which chains cannot be applied.

Drop doors on heavy capacity cars should be constructed with as little mechanism as possible, and at the same time the weight should be such that a man of ordinary strength can close them, as the operating of the doors is always in the hands of the inexperienced, who often are unable physically to close some of them without assistance.

The floor sheets are of the same thickness as the side sheets. If there is any reason for this I have not discovered it. Floor sheets should be heavier than the side sheets, especially on gondola cars, for the floor sheets wear and rust out long before the side sheets, and when it becomes necessary to renew the floor sheets they must be separated from the side sheets which also show signs of deterioration, especially where they join. In making repairs we cannot help but distort the rivet holes and often tear the side plates. I believe if the floor sheets were heavier the possibility of both sheets wearing out together would be greater and their renewal would insure better results in workmanship and service.

It is noticeable on all gondola cars that the floor sheets sag, forming pockets between the center sills, or, in fact, at any point where there is no support underneath. This, of course, is due to the deterioration of the plates, or the kind of service the cars are in. During wet weather these pockets are filled with water for days at a time on account of insufficient pertoration in the floor sheets; this is very injurious, as the only escape for the water is by evaporation.

Maintenance.

I consider the maintenance of steel cars as not nearly as difficult a proposition under present conditions as the maintenance of wood cars. The road with which I am connected has about 58 per cent. steel equipment, and I wish it was 100 per cent. We do not find it difficult to take proper care of it, but, of course, it is necessary to equip the repair plant with a sufficient number of machines and tools suitable for the work.

I would strongly recommend that all the work be done under cover. With the thermometer near zero it is impossible to heat and straighten repair parts and drive rivets outside, and the result is your repair plant is practically disabled. This is expensive when cars are needed.

Following are a few important machines and tools which I consider necessary to have installed in a steel car repair shop, coming directly under the supervision of the car department. When so installed there is no reason why all despatch work cannot be completed satisfactorily, thereby relieving you of considerable anxiety as to whether some other department (which has all they can do to get out their own rush jobs) is going to finish yours in seasonable time.

A drill press is very necessary, especially when making repairs to foreign cars, for drilling carry irons, draft straps, foot board brackets, truck spring hangers, or other parts which cannot be punched.

A flanging clamp for flanging floor sheets, side sheets, angles, etc.

A stationary riveter, to be used for riveting parts removed for repairs, such as drop doors, door spreaders, draft lugs, truck bolster top plates, stakes to side sheets, etc. I would suggest that as much work as possible be done on the stationary riveters, for the cost per rivet is fully two-thirds less than if driven by hammer.

An air or hydraulic press, fully equipped with formers or dies for the purpose of straightening different shaped material is very essential.

Shears, and punches, and angle, flat, square and round cutters are also necessary. A combination machine capable of performing all of this work can be procured in the open market, and when the shop room is limited it is very desirable.

A steel car jack.* This is not an expensive device, and is certainly a paying investment. It can be used to the very best advantage for jacking cars back into shape, while cold, which have been twisted or bulged by accident. I recall many cases where this device has saved thirty to fifty dollars labor per car.

* See January issue, page 5.

A good-sized heating furnace to admit the largest car sheet and to accommodate about five thousand pounds of various kinds of plates, end sills, etc., is another necessity. A furnace with inside dimensions of 2 ft. 4 in. x 8 ft. x 13 ft. will accommodate this amount of material. By keeping in stock a sufficient amount of new standard parts it will not be necessary to keep the furnace in constant use. I have worked very successfully by using new material to replace damaged parts, allowing the damaged parts to accumulate until there was a sufficient amount on hand to justify heating the furnace, and find it more economical to manage it this way. All material which is straightened or repaired is placed in stock to be used on the next cars that come in. In front of the furnace an iron working plate about 5½ in. x 3 ft. 3 in. x 10 ft. should be placed with the necessary clamps for holding the bent parts in place while they are being straightened.

In every steel car shop, where there is sufficient work to warrant it, there should be an overhead crane for lifting the cars onto trestles instead of jacking; it can also be used for placing and holding the plates until secured by the workmen. By using a crane a couple of men on the ground will handle the largest plates used, otherwise a scaffold and a number of men are necessary to raise a plate and fasten it, accompanied by more or less danger to the men.

Organization.

When equipped, as outlined, I have found that on the heaviest of steel car repairs two men are able to handle most of the repairs, but find it practicable to place a gang of six men on three cars and by dividing them into three gangs they can do their own cutting apart, fitting up and riveting, and not be detained by material, which in the meantime is being straightened or machined. I have operated separate gangs to cut apart, fit up, and rivet, but with little success, for it is immaterial to the men who cut apart as to what becomes of the parts removed, and the gangs following lose considerable time in locating the parts when needed. It is also practicable to have stationary rivet heating furnaces in the car shop, placed so that each furnace can supply rivets to three gangs of six men each.

Painting.

Painting of steel cars is of the utmost importance, and where we have a great number of them, the repainting process is continuous. A suitable freight car paint shop should be provided, for the painting cannot be done outside in inclement weather. When equipment needs painting you cannot afford to neglect it until favorable weather comes. As a rule, in the summer months the equipment is busy, and there is little opportunity to withdraw it from service, except in cases of emergency. Newly built cars, when ready for the first painting, should have all the flash and rust removed. Unless this is done the flash and paint will continue to fall off in spots as long as any flash remains. In order to remove the flash thoroughly I would recommend the sand blast process. When it is not possible to use this method, would suggest dry cleaning, using steel scratch brushes, sand stone, or any tool which will answer the purpose. Following either process would suggest the application of three coats of paint at twenty-four-hour intervals. Later on, when repainting is necessary, the sand blast should again be used. If this cannot be done, dry clean, and apply two coats of good paint. After taking these precautions to protect the exterior, we find that under ordinary conditions it is necessary to repaint at the expiration of about three years; where conditions are unfavorable to the equipment, the repainting should be governed accordingly.

I cannot be too emphatic as to the necessity of taking the proper care of the exterior, and regret that the interior cannot receive the same attention, but occasionally spraying the interior with crude oil may be found beneficial. At the present time the P. & L. E. R. R. are testing this idea, and I am very sorry the test is not completed so as to enable me to give you the results.

The best of paint should be used in order to prevent rust after painting. The paint which has the greatest wearing elasticity is preferable, as there is less liability for the penetration of moisture. Adhesion is just as important, and to have perfect adhesion the paint should dry from the inside out, the same as good varnish. By using the best materials we need not fear the expansion and contraction of the plates as long as the elasticity remains.

Cost of Repairs.

Following are some data showing the relative cost of repairs to steel and wood cars, which I am confident is correct so far as it pertains to the P. & L. E. R. R. equipment repaired on its lines:

100 WOOD CARS REQUIRING HEAVY REPAIRS.

Cost of material	$2,521.00	Average per car	$25.21
Labor and supervision	1,631.00	" " "	16.31
Total	$4,152.00	Total	$41.52

100 STEEL CARS REQUIRING HEAVY REPAIRS.

Cost of material	$3,424.00	Average per car	$34.24
Labor and supervision	2,292.00	" " "	22.92
Total	$5,716.00	Total	$57.16

A very accurate record was kept of the average number of times the different classes of cars were called into the shop for light, medium and heavy repairs, covering a period of one year.

Average number of times one wood coal car was in shop during one year	7 times
Average cost of repairs each time in shop	$16.23
Average number of times one wood coke car was in shop during one year	6 times
Average cost of repairs each time in shop	$10.74
Average number of times one steel car was in shop during one year	1 1/3 times
Average cost of repairs each time in shop	$6.74

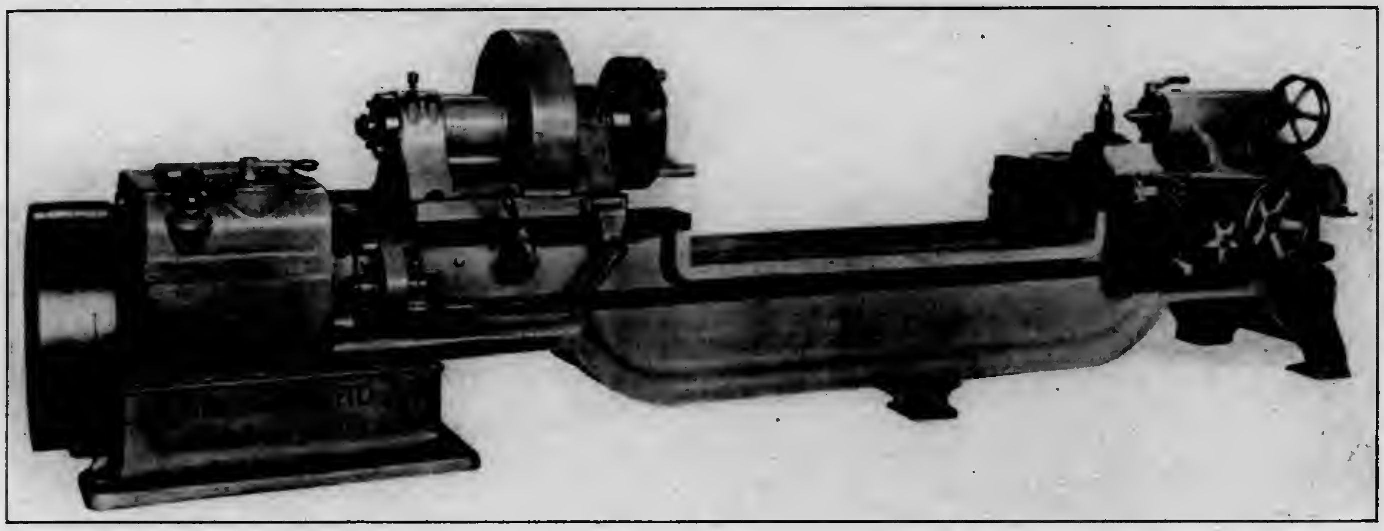
The above figures represent the cost of material and labor, less scrap credits, and is the average cost of the total repairs to:—

806	Heavy steel car repairs,
1,352	Medium " " "
9,180	Light " " "
11,338	
707	Heavy wood coal car repairs,
513	" " coke " "
3,018	Medium " coal " "
3,354	" " coke " "
12,438	Light " coal " "
12,040	" " coke " "
32,070	

Your attention is called particularly to the number of times a steel and a wood car are called into the shop per year, and to the difference in the cost of maintenance per car. Of course, it must be understood that when the time comes to renew the steel car parts which are worn out, the figures shown will be inadequate for the reason that we are comparing steel cars with a collection of new and old wood cars, but even so, I believe, if we give the steel cars the proper care their maintenance will be less in the end than that of wood cars.

Skill with the Scoop means economy in the use of fuel, but better still, it means a good steamer, while a lack of knowledge makes a poor steamer. It takes steam to move trains and plenty of steam means quick dispatch, which is a much-neglected form of economy in these days of heavy tonnage trains that move so slowly that they tie up the road and keep the yards blocked.—*C. B. Conger before the Traveling Engineers' Association.*

Cables of the Manhattan Bridge.—The cables of the new Manhattan bridge which is now in course of construction will consist of 9,472 steel wires, each being slightly over 3/16 in. diameter. This will make the finished cables about 21½ inches diameter. Each wire has a tensile strength of about 6,000 lbs., making the strength of each cable over 28,000 lbs. There are to be four of these cables in the bridge.



BRIDGEFORD HEAVY GAP LATHE FOR REFINISHING CAR AXLES.

HEAVY GAP LATHE.

The heavy gap lathe, illustrated herewith, is manufactured by the Bridgeford Machine Tool Works, Rochester, N. Y., and is intended for refinishing car axle journals without removing the wheels; it may also be used as a single end axle lathe, it being possible to move the headstock on the bed, by the rack and pinion, so as to bring the wheel fit within the range of the carriage. It may also be arranged for refinishing engine truck axle journals by providing an extra carriage between the wheels, leaving a short gap on each side.

The machine is driven through the 30 in. pulley by an 8 in. belt. Three different speeds may be obtained by a mechanical speed changing device, which is operated by levers, conveniently located on the casing to the right of the driving pulley. The gears in this device are all of heavy cut steel and run in oil. The power is transmitted from the change speed device to the driving head by a shaft, placed within the frame, and a set of gears. The driving head is of very strong construction and the end thrust on the spindle is taken up by an adjustable step. The driving gear is entirely encased and the head is furnished with a double self-centering steel driver.

The tailstock is of the ordinary type of construction and has a bearing on the bed 24 in. in length. It may be set over for taper turning when desired. The carriages are driven by a splined feed shaft, through a rack and pinion. The direction of the feed is changed at the apron, the carriages being independent of each other. A feed-box, operated by a lever conveniently placed in front of the headstock, furnishes four changes of feed, ranging from 1/16 to 3/16 in., to one turn of the axle. The carriages have a bearing at the back of the bed, which takes up the forward thrust, thus overcoming the tendency to raise them from the V's when the burnisher is used. The bed is of rigid construction strongly reinforced by cross ties of box pattern. The swing over the ways is 27 in.; over the carriage 14 in. and in the gap 45 in. The distance between centers is 8 ft. 4 in. The weight of the machine is about 15,500 lbs.

ASSOCIATION OF CAR LIGHTING ENGINEERS.

At a meeting held in the office of E. W. Newcomb, signal engineer, O. S. L. R. R., at Ogden, May, 1908, an organization was formed to be known as the Association of Car Lighting Engineers; the following officers were elected:

President, A. J. Farrely, electrical engineer, C. & N. W. R. R.; first vice-president, E. M. Cutting, signal supervisor, S. P. System; second vice-president, A. J. Collett, electrical engineer, U. P. R. R. Co.; secretary and treasurer, G. B. Colgrove, chief electrician, I. C. R. R. Executive committee: H. C. Malloy, chief electrician, L. S. & M. S. R. R.; O. W. Ott, chief draftsman, O. S. L. R. R.; G. W. Murray, chief electrician, S. P. L. A. & S. L. R. R.; C. W. Terry, chief electrician, Soo Line.

Membership in the association is to be divided into active and associate members. For active membership all men directly or indirectly in charge of electric car lighting on any railroad in the United States or Canada are eligible. For associate membership all men who have been engaged in electric car lighting work for a period of over one year on any railroad in the United States or Canada are eligible, on recommendation of their superior; representatives of all companies engaged in the railway supply business are also eligible to associate membership.

At the first meeting a general discussion of train lighting matters was indulged in and the president was authorized to assign a list of subjects upon which papers will be prepared by the different members, as designated by the president, for discussion at the next meeting. The object of this association is to further the interests of car lighting, particularly electric car lighting, and try to bring about standards covering interchanged equipment on the various railroads of the United States and Canada. It is the intention to hold meetings once a year, or oftener, at which subjects pertaining to train lighting will be discussed in a similar manner to that now in vogue at the various railway clubs. The next meeting of the association will be held in Chicago some time in October.

The Magnitude of the Baggage Department of a big railway, as well as the many curious items it covers, was well illustrated by a statement recently issued by the baggage officials of the Canadian Pacific Ry., showing their business for the past year. 7,630,139 pieces of baggage were handled during the year. This is an increase of 1,305,008 pieces over the record of last year. For this service the company received excess baggage charges, storage charges, special delivery, etc., amounting to $339,178. It is noticeable in the report that there were large increases in every line of baggage business except bicycles, showing that the passenger business has not suffered anything like the decline that has marked the freight department of railroad work during the past six months. During the year the Canadian Pacific baggage department handled 16,003 bicycles, 12,427 dogs, 8,153 baby carriages, and 1,461 corpses, the latter having to travel as baggage on regular passenger tickets. The bicycle traffic dropped by over a thousand from the previous year, everything else, however, showing an increase, dogs going up from 11,198 to 12,427, and baby carriages almost doubling in number

---

The Engineer and His Work.—It is distinctly the business of the engineer to lessen waste—wastes of material, wastes of friction, wastes of design, wastes of effort, wastes due to crude organization and administration—in a word, wastes due to inefficiency. The field is the largest and richest into which any worker was ever turned.—*Harrington Emerson in The Engineering Magazine.*

15-INCH SINGLE GEARED CRANK SHAPER.

The American Tool Works Company, of Cincinnati, has recently brought out a new 15 in. single geared crank shaper which embodies a number of important improvements. Some idea of the capacity of this machine may be gained from the following data from tests made at the works.

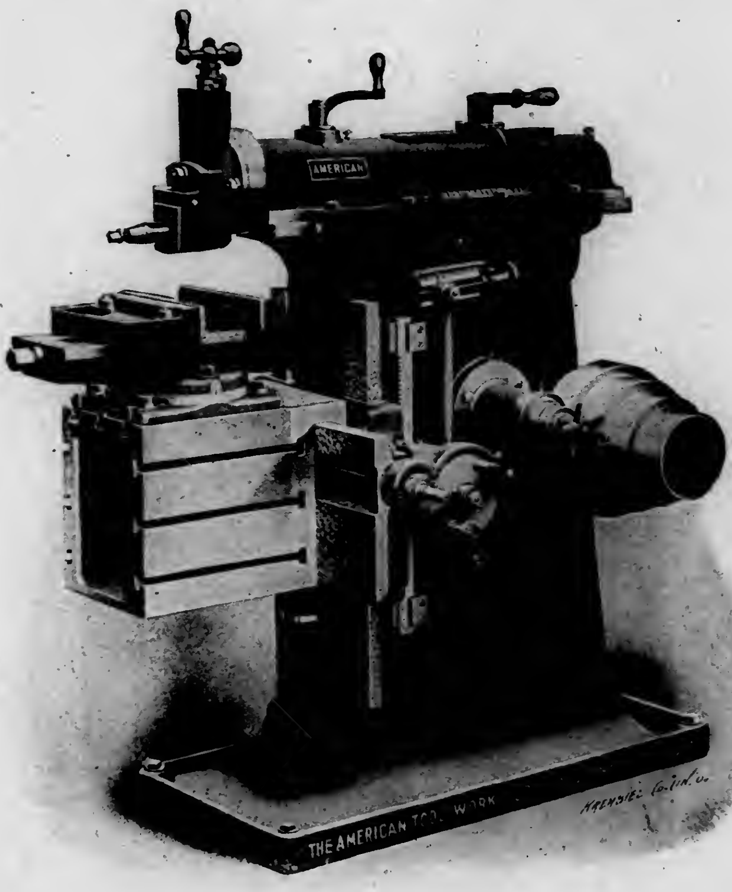
CAST IRON TEST.

3/8" deep,	.016 feed,	2 notches,	4"	long,	30 strokes	per min.
1/8" "	.040 "	5 "				
1/8" "	.048 "	6 "				
1/8" "	.024 "	3 "	12"	"	20 "	" "

STEEL TEST.

1/8" deep,	.016 feed,	2 notches,	2½"	long,	30 strokes	per min.
1/8" "	.016 "	2 "	10"	"	20 "	" "

The shaper is of heavy and substantial design to meet the most severe requirements. The stroke of the ram is positive



AMERICAN SINGLE GEARED CRANK SHAPER.

and has four rates of speed ranging from 20 to 65 strokes per minute. The length of the stroke may easily be changed without stopping the machine. The device for positioning the stroke is located on the ram near the head and may be manipulated while the machine is in operation. The pointer on the ram and an index indicate the length of the stroke. The rocker arm, of rigid and heavy construction, is so arranged as to give the ram a practically uniform rate of speed during the entire stroke; it also provides for an exceedingly quick return. The driving mechanism is sufficiently powerful for the heaviest work adapted to this type of machine.

The cross feed is of a new patented design, is variable and automatic, and has a range of from .008 to .200 in., any one of the feeds being instantly obtainable while the machine is in operation. It is supplied with a pointer and graduations either side of zero reading from 1 to 25 notches, each notch representing .008 feed. The feed mechanism is so constructed as to render unnecessary any adjustment due to a change in position of the rail. The feed may be thrown in or out or reversed through the knob on the large feed gear. This gear is also supplied with a square rod to receive a crank, by which the table may be quickly advanced or returned.

The column is deep and wide, slightly tapering toward the top, and is carefully braced and reinforced internally, so as to make it very rigid. It projects at the top at both the front and the rear, providing a long bearing for the ram. The base is deep and strongly ribbed and of pan construction to catch all oil drippings, thus protecting the floor. The ram is carefully designed to afford uniform rigidity throughout the length of the stroke and has large bearings on the column with a continuous taper gib, having an end screw attachment for taking up wear. The head may be operated at any angle within an arc of 100 degs. The down slide is fitted with a continuous taper gib having an end screw adjustment for taking up wear. The down feed is of unusual length, the feed screw having an adjustable graduated collar reading to .001 in. It is equipped with a large tool post for using holders with inserted cutters.

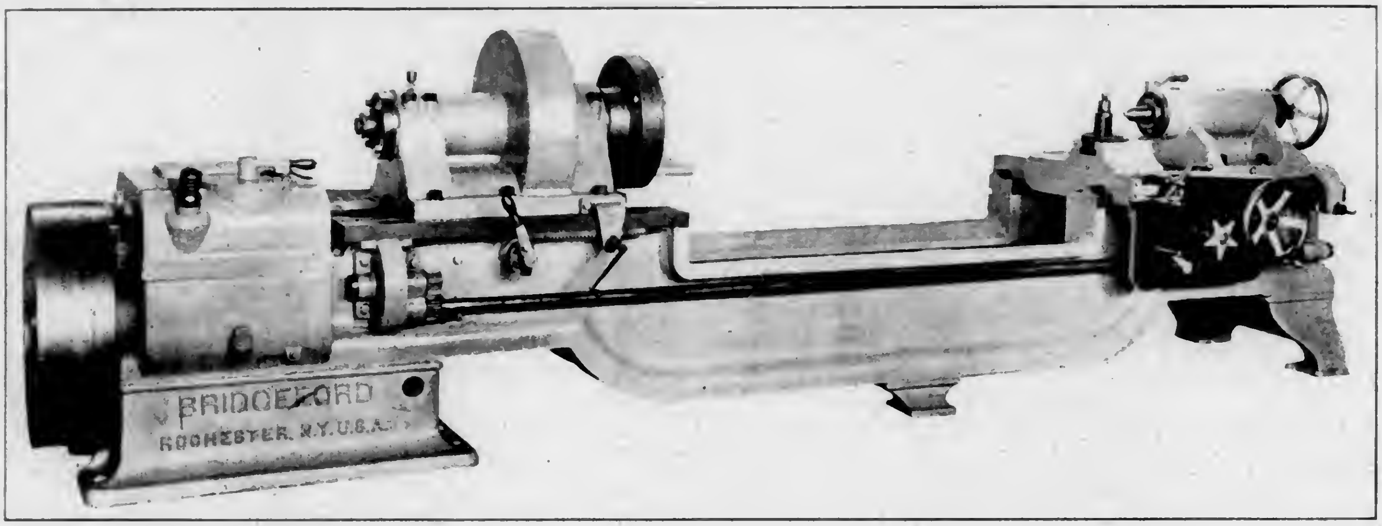
The table is of substantial construction and is readily detachable. The apron is provided with a continuous taper gib having an end screw adjustment for taking up wear and has T slots for clamping work when the table is removed. An automatic stop releases the feed and thus prevents breakage when the tool is fed into the cut or if the apron should accidentally be fed to its limit in either direction. The cross rail is of box form, is of exceptional length and provided with a large diameter telescopic elevating screw, having a ball bearing thrust bearing.

The rocker arm is of double section at the top, and this, in connection with an opening in the column, permits the key-seating of shafts as large as 2½ in. in diameter. Larger shafts may be key-seated by setting over the table and setting the head at an angle. Special attention has been given to the lubrication of all parts. The ram slides are provided with felt wipers at both the front and center of the column, assisting in perfect lubrication, also preventing oil from dripping down over the front of the machine. An oil pocket is cast integral with the column at the rear, storing any waste of oil, which may be drawn off at any time through a pipe extending from the rear of the column. A large quantity of oil is stored in a pocket cast integral with the arm with suitable means of distribution, insuring thorough lubrication of the crank pin and the sliding block in the rocker arm. The maximum length of stroke is 15¼ in.; the down feed to the head is 6 in.; the vertical travel of the table is 14 in.; the horizontal travel is 18 in.

SKILL IN HANDLING THE REVERSE LEVER AND THROTTLE gets as many heavy trains in on time as big locomotives carrying a high steam pressure. Skill with the injector counts for as much as skill with the scoop if the steam gauge is any guide.—*C. B. Conger before the Traveling Engineers' Association.*

MECHANICAL DRAFTSMEN WANTED.—The United States Civil Service Commission announces an examination on October 21 to 23 inclusive, to secure eligibles for the position of skilled mechanical draftsman in the ordnance department. The salary to start with will be from $1,000 to $1,200 a year. Application should be made to the United States Civil Service Commission, Washington, D. C., for information concerning the examination. It will be necessary for the applications to be properly executed and filed before October 10th.

RAILWAY SIGNAL ASSOCIATION.—The twelfth annual convention of this association will be held in the New Willard Hotel, Washington, D. C., October 13, 14 and 15. A booklet is being issued by the secretary, C. C. Rosenberg, 12 Linden street, Bethlehem, Pa., which includes the program for the meeting, a list of the members of the different committees and a complete list of all members of the association with their positions and addresses.



BRIDGEFORD HEAVY GAP LATHE FOR REFINISHING CAR AXLES.

HEAVY GAP LATHE.

The heavy gap lathe, illustrated herewith, is manufactured by the Bridgeford Machine Tool Works, Rochester, N. Y., and is intended for refinishing car axle journals without removing the wheels; it may also be used as a single end axle lathe, it being possible to move the headstock on the bed, by the rack and pinion, so as to bring the wheel fit within the range of the carriage. It may also be arranged for refinishing engine truck axle journals by providing an extra carriage between the wheels, leaving a short gap on each side.

The machine is driven through the 30 in. pulley by an 8 in. belt. Three different speeds may be obtained by a mechanical speed changing device, which is operated by levers, conveniently located on the casing to the right of the driving pulley. The gears in this device are all of heavy cut-steel and run in oil. The power is transmitted from the change speed device to the driving head by a shaft, placed within the frame, and a set of gears. The driving head is of very strong construction and the end thrust on the spindle is taken up by an adjustable step. The driving gear is entirely encased and the head is furnished with a double self-centering steel driver.

The tailstock is of the ordinary type of construction and has a bearing on the bed 24 in. in length. It may be set over for taper turning when desired. The carriages are driven by a splined feed shaft, through a rack and pinion. The direction of the feed is changed at the apron, the carriages being independent of each other. A feed-box, operated by a lever conveniently placed in front of the headstock, furnishes four changes of feed, ranging from 1/16 to 3/16 in., to one turn of the axle. The carriages have a bearing at the back of the bed, which takes up the forward thrust, thus overcoming the tendency to raise them from the V's when the burnisher is used. The bed is of rigid construction strongly reinforced by cross ties of box pattern. The swing over the ways is 27 in.; over the carriage 14 in. and in the gap 45 in. The distance between centers is 8 ft. 4 in. The weight of the machine is about 15,500 lbs.

ASSOCIATION OF CAR LIGHTING ENGINEERS.

At a meeting held in the office of E. W. Newcomb, signal engineer, O. S. L. R. R., at Ogden, May, 1908, an organization was formed to be known as the Association of Car Lighting Engineers; the following officers were elected:

President, A. J. Farrely, electrical engineer, C. & N. W. R. R.; first vice president, E. M. Cutting, signal supervisor, S. P. System; second vice-president, A. J. Collett, electrical engineer, U. P. R. R. Co.; secretary and treasurer, G. B. Colgrove, chief electrician, I. C. R. R. Executive committee: H. C. Malloy, chief electrician, L. S. & M. S. R. R.; O. W. Ott, chief draftsman, O. S. L. R. R.; G. W. Murray, chief electrician, S. P. L. A. & S. L. R. R.; C. W. Terry, chief electrician, Soo Line.

Membership in the association is to be divided into active and associate members. For active membership all men directly or indirectly in charge of electric car lighting on any railroad in the United States or Canada are eligible. For associate membership all men who have been engaged in electric car lighting work for a period of over one year on any railroad in the United States or Canada are eligible, on recommendation of their superior; representatives of all companies engaged in the railway supply business are also eligible to associate membership.

At the first meeting a general discussion of train lighting matters was indulged in and the president was authorized to assign a list of subjects upon which papers will be prepared by the different members, as designated by the president, for discussion at the next meeting. The object of this association is to further the interests of car lighting, particularly electric car lighting, and try to bring about standards covering interchanged equipment on the various railroads of the United States and Canada. It is the intention to hold meetings once a year, or oftener, at which subjects pertaining to train lighting will be discussed in a similar manner to that now in vogue at the various railway clubs. The next meeting of the association will be held in Chicago some time in October.

The Magnitude of the Baggage Department of a big railway, as well as the many curious items it covers, was well illustrated by a statement recently issued by the baggage officials of the Canadian Pacific Ry., showing their business for the past year. 7,630,139 pieces of baggage were handled during the year. This is an increase of 1,305,608 pieces over the record of last year. For this service the company received excess baggage charges, storage charges, special delivery, etc., amounting to $339,178. It is noticeable in the report that there were large increases in every line of baggage business except bicycles, showing that the passenger business has not suffered anything like the decline that has marked the freight department of railroad work during the past six months. During the year the Canadian Pacific baggage department handled 16,003 bicycles, 12,427 dogs, 8,153 baby carriages, and 1,461 corpses, the latter having to travel as baggage on regular passenger tickets. The bicycle traffic dropped by over a thousand from the previous year, everything else, however, showing an increase; dogs going up from 11,108 to 12,427, and baby carriages almost doubling in number.

The Engineer and His Work.—It is distinctly the business of the engineer to lessen waste—wastes of material, wastes of friction, wastes of design, wastes of effort, wastes due to crude organization and administration—in a word, wastes due to inefficiency. The field is the largest and richest into which any worker was ever turned.—*Harrington Emerson in The Engineering Magazine.*

15-INCH SINGLE GEARED CRANK SHAPER.

The American Tool Works Company, of Cincinnati, has recently brought out a new 15 in. single geared crank shaper which embodies a number of important improvements. Some idea of the capacity of this machine may be gained from the following data from tests made at the works.

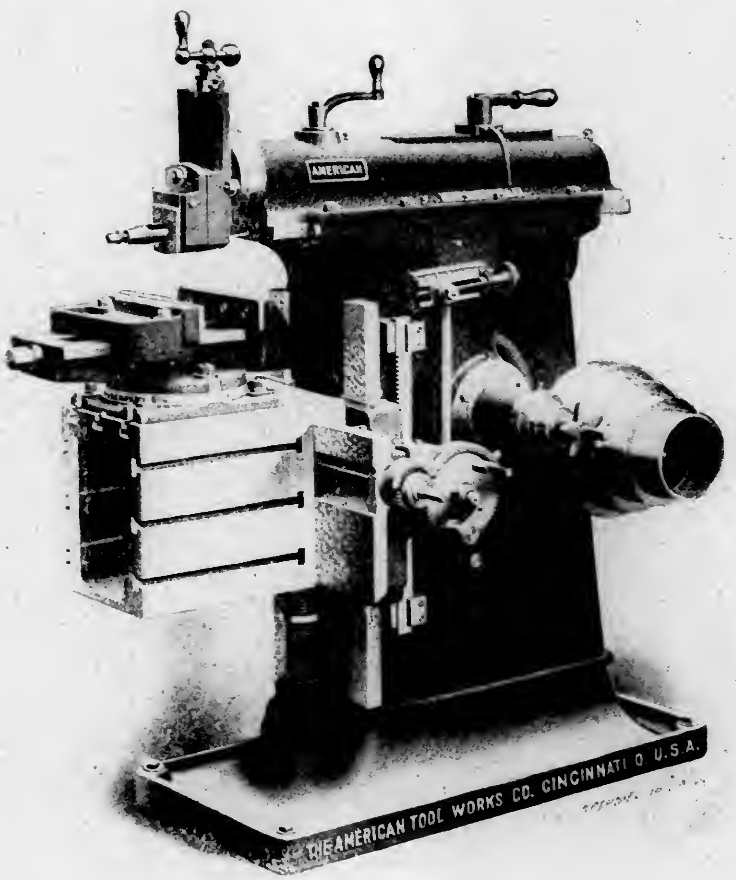
CAST IRON TEST.

[illegible]" deep,	.016 feed,	2 notches,	}				
[illegible]" "	.010 "	5 "	}	4"	long,	30 strokes per min.	
[illegible]" "	.018 "	6 "	}				
[illegible]" "	.024 "	3 "		12"	"	20 "	" "

STEEL TEST.

[illegible]" deep,	.016 feed,	2 notches,	2½"	long,	30 strokes per min.
[illegible]" "	.016 "	2 "	10"	"	20 " " "

The shaper is of heavy and substantial design to meet the most severe requirements. The stroke of the ram is positive and has four rates of speed ranging from 20 to 65 strokes per minute. The length of the stroke may easily be changed without stopping the machine. The device for positioning the stroke is located on the ram near the head and may be manipulated while the machine is in operation. The pointer on the ram and an index indicate the length of the stroke. The rocker arm, of rigid and heavy construction, is so arranged as to give the ram a practically uniform rate of speed during the entire stroke; it also provides for an exceedingly quick return. The driving mechanism is sufficiently powerful for the heaviest work adapted to this type of machine.



AMERICAN SINGLE GEARED CRANK SHAPER.

The cross feed is of a new patented design, is variable and automatic, and has a range of from .008 to .200 in., any one of the feeds being instantly obtainable while the machine is in operation. It is supplied with a pointer and graduations either side of zero reading from 1 to 25 notches, each notch representing .008 feed. The feed mechanism is so constructed as to render unnecessary any adjustment due to a change in position of the rail. The feed may be thrown in or out or reversed through the knob on the large feed gear. This gear is also supplied with a square rod to receive a crank, by which the table may be quickly advanced or returned.

The column is deep and wide, slightly tapering toward the top, and is carefully braced and reinforced internally, so as to make it very rigid. It projects at the top at both the front and the rear, providing a long bearing for the ram. The base is deep and strongly ribbed and of pan construction to catch all oil drippings, thus protecting the floor. The ram is carefully designed to afford uniform rigidity throughout the length of the stroke and has large bearings on the column with a continuous taper gib, having an end screw attachment for taking up wear. The head may be operated at any angle within an arc of 100 degs. The down slide is fitted with a continuous taper gib having an end screw adjustment for taking up wear. The down feed is of unusual length, the feed screw having an adjustable graduated collar reading to .001 in. It is equipped with a large tool post for using holders with inserted cutters.

The table is of substantial construction and is readily detachable. The apron is provided with a continuous taper gib having an end screw adjustment for taking up wear and has T slots for clamping work when the table is removed. An automatic stop releases the feed and thus prevents breakage when the tool is fed into the cut or if the apron should accidentally be fed to its limit in either direction. The cross rail is of box form, is of exceptional length and provided with a large diameter telescopic elevating screw, having a ball bearing thrust bearing.

The rocker arm is of double section at the top, and this, in connection with an opening in the column, permits the key-seating of shafts as large as 2½ in. in diameter. Larger shafts may be key-seated by setting over the table and setting the head at an angle. Special attention has been given to the lubrication of all parts. The ram slides are provided with felt wipers at both the front and center of the column, assisting in perfect lubrication, also preventing oil from dripping down over the front of the machine. An oil pocket is cast integral with the column at the rear, storing any waste of oil, which may be drawn off at any time through a pipe extending from the rear of the column. A large quantity of oil is stored in a pocket cast integral with the arm with suitable means of distribution, insuring thorough lubrication of the crank pin and the sliding block in the rocker arm. The maximum length of stroke is 15¼ in.; the down feed to the head is 6 in.; the vertical travel of the table is 14 in.; the horizontal travel is 18 in.

SKILL IN HANDLING THE REVERSE LEVER AND THROTTLE gets as many heavy trains in on time as big locomotives carrying a high steam pressure. Skill with the injector counts for as much as skill with the scoop if the steam gauge is any guide.—*C. B. Conger before the Traveling Engineers' Association.*

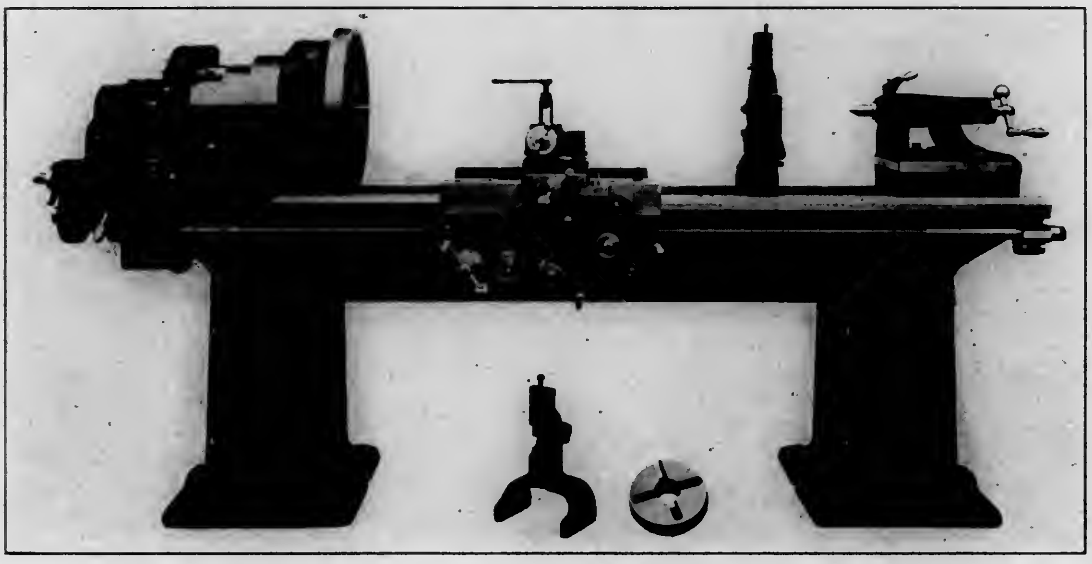
MECHANICAL DRAFTSMEN WANTED.—The United States Civil Service Commission announces an examination on October 21 to 23 inclusive, to secure eligibles for the position of skilled mechanical draftsman in the ordnance department. The salary to start with will be from $1,000 to $1,200 a year. Application should be made to the United States Civil Service Commission, Washington, D. C., for information concerning the examination. It will be necessary for the applications to be properly executed and filed before October 10th.

RAILWAY SIGNAL ASSOCIATION.—The twelfth annual convention of this association will be held in the New Willard Hotel, Washington, D. C., October 13, 14 and 15. A booklet is being issued by the secretary, C. C. Rosenberg, 12 Linden street, Bethlehem, Pa., which includes the program for the meeting, a list of the members of the different committees and a complete list of all members of the association with their positions and addresses.

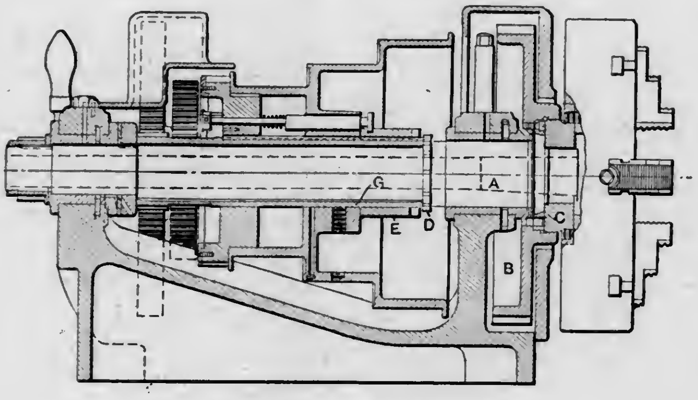
18-INCH CONE-HEAD ENGINE LATHE.

An 18 in. by 8 ft., cone-head, Schellenbach, engine lathe, made by The John B. Morris Foundry Company, Cincinnati, O., is illustrated herewith. It is of the same general design as the geared-head lathe, made by this company, except that the cone-head is used.

A sectional view of the headstock is shown on the drawing. The spindle A has a flange at its right end and receives the face gear B, which is dowled and screwed to it. This face gear B has internal threads and receives the face plate or the chuck. It will be seen that the chuck plate C fits the counterbore of the chuck and is bored to fit the end of the spindle and threaded on the outside to screw into the face gear B. Thus, when pressure is exerted against the chuck it clamps the flange of the spindle tightly between the chuck plate, C, and the face gear, B. This arrangement eliminates tortional strains within the spindle when running in back gear. Clutch teeth D are formed upon the spindle and engage the clutch E, which is splined to the cone pinion sleeve G. This clutch is operated at the back end of the headstock by a spring seated plunger which passes through the cone pulley. The plunger is provided with a knurl with a detent pin for holding it out of engagement.



SCHELLENBACH 18-INCH CONE-HEAD ENGINE LATHE.



CROSS-SECTION OF HEADSTOCK.

A three step cone is provided for a 2 in. double belt, the largest diameter being 12 in.; there are two changes of back gearing, making in all nine changes of speed with a single speed of the countershaft. The countershaft is provided with double friction pulleys, and where back motion is not needed it may be driven at two different speeds, thus giving the spindle six open belt speeds and twelve back gear speeds. The back gear is operated with an eccentric shaft in the ordinary manner. It will be noticed that the overhang of the chuck, from the face of the jaws to the front spindle bearing, is not as great as with the ordinary type of lathe. All gearing on the head is enclosed and is of coarse pitch.

A quick change device gives a range of threads from 2 to 112. A double plate apron and a special feature for rough chasing threads by the ordinary rack feed in place of the lead screw are provided, the object being to preserve the accuracy of the screw and to use it for only accurate chasing. A single wrench operates every adjusting screw throughout the machine, including the tightening of the tail-stock to the shears. The cabinet legs have hinged doors with latches operated by knobs. This lathe is also made in 14 and 16 in. sizes, and with a plain system of change gears, as well as with the quick change, as shown.

RAILROAD REPAIR SHOP ARRANGEMENT.

Certain fundamental principles should be recognized before attempting a railroad shop arrangement, and as far as possible the arrangement should be worked over until it satisfies these requirements, always recognizing exceptions due to individual conditions.

(1) Liberal space (say 100 per cent.) should be allowed for the extension of each department.

(2) The store house (with administrative offices in one of the upper floors) should be central, convenient to all departments, and easy of access on two tracks from the main line service track.

(3) The forge shop should be convenient to both the locomotive and car repair departments.

(4) The power house should be central and near the planing mill and repair tracks in order to burn refuse.

(5) Yard cranes should be arranged to serve between the store house platforms and all departments.

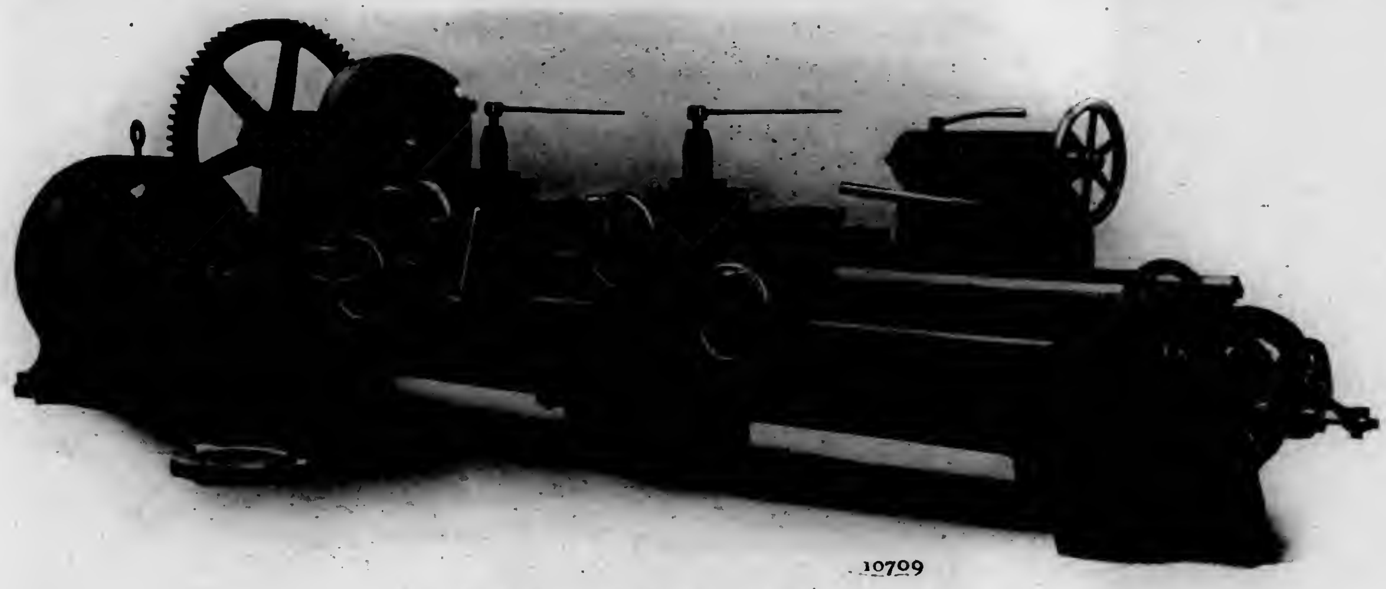
(6) The roundhouse should be very near the shop, or located far enough away to justify a separate machine shop for light repairs.

(7) Tracks, cranes, telphers, and storage spaces should be arranged to insure the movement of materials with the greatest economy of time and labor.

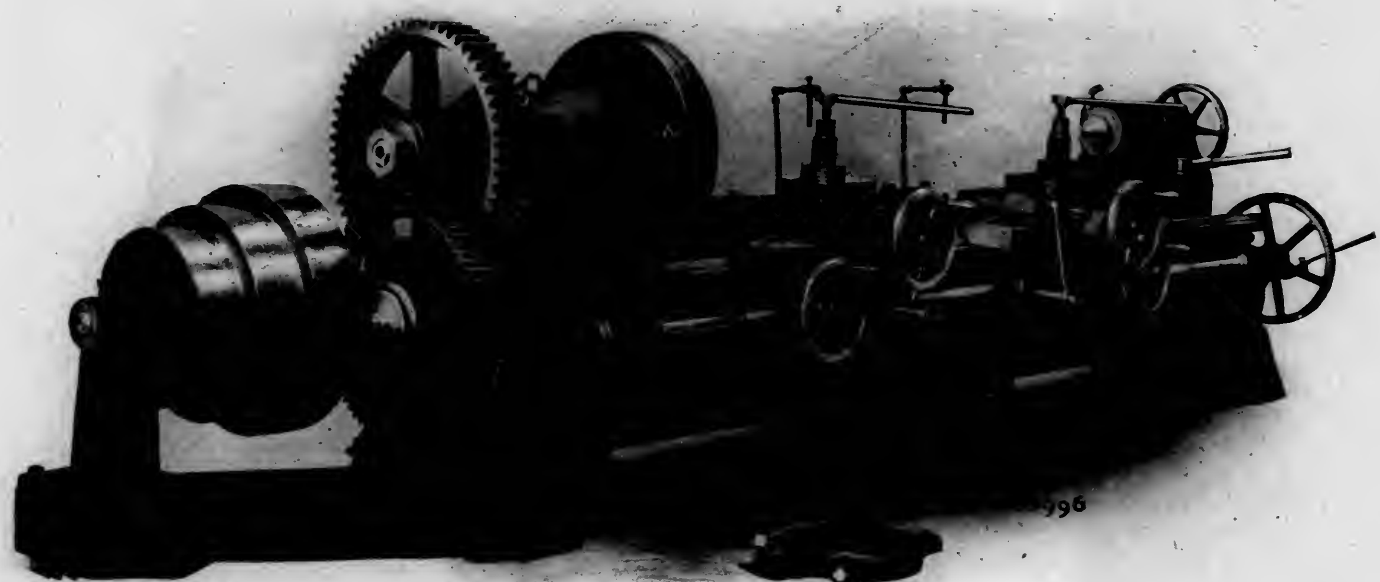
(8) Some consideration should be given to the appearance of the shops and accessory storage facilities, lumber yards, etc., from the main line.

(9) The advantages of a short tunnel of ample cross section for the use of the various steam air, and water piping systems should not be forgotten.

(10) The possibilities of the adoption of longer and heavier



NILES LOCOMOTIVE AXLE LATHE, MOTOR DRIVEN.



LOCOMOTIVE AXLE LATHE, NILES-BEMENT-POND COMPANY.

engines similar to the consolidation or articulated types should be considered, and some provision made for present or future repair facilities for these larger engines.

(11) The cost of the shops should be consistent with not only the actual necessities, but in proportion to the refinements which the road can afford. All expenditures over and above those required for actual needs should be capitalized and made to show a satisfactory return on the investment.—*George A. Damon before the Canadian Railway Club.*

LOCOMOTIVE AXLE LATHE.

The locomotive axle lathe, shown in the illustrations, is made at the Niles works of the Niles-Bement-Pond Co. and is of a very substantial design, intended for turning the heaviest driving axles. It has a swing of 14 in. over the carriage and a maximum distance between centers of 8 ft. The axle is driven by the double equalizing driver plate. The tail stock is of the usual form. The two carriages, right and left hand, are equipped with a positive power feed having three changes. Both carriages have opening nuts, quick hand movement and hand cross feed.

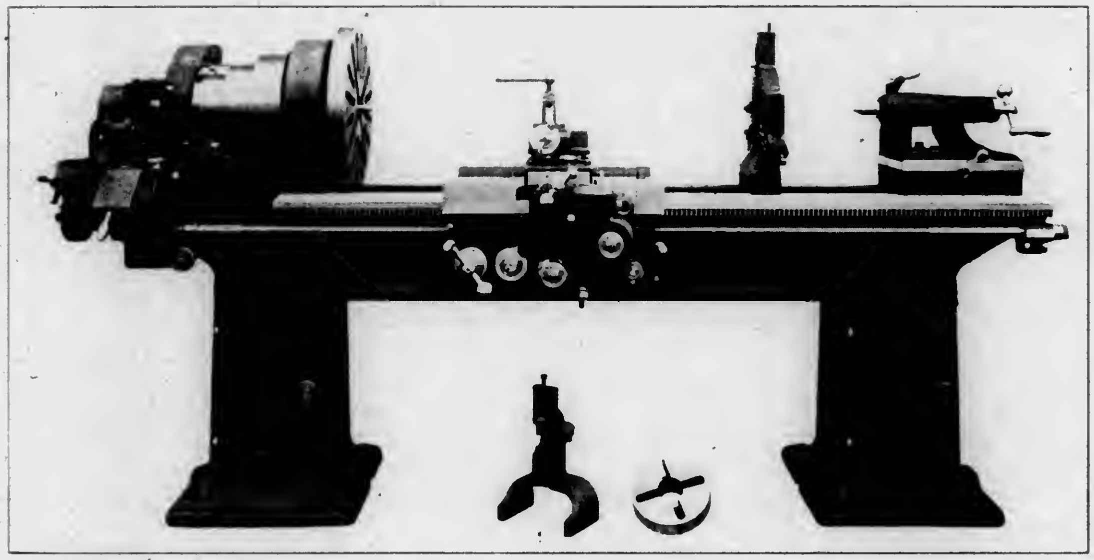
A pump keeps the lubricant in circulation, it being collected in a reservoir in the center leg of the machine. Brackets are placed at the back of the machine to which formers of any desired shape may be attached for giving the proper contour to the axle. Where desired a crane with a convenient hand hoist for lifting the axle in and out may be placed at the back of the bed. With the belt driven machine a 5½ in. belt is used; the lathe may be driven by a direct connected variable speed motor of 25 h.p. capacity, mounted on a plate attached to the bed as shown.

ELECTRICITY IN AGRICULTURE.—In England, electricity has been experimentally applied to agriculture on a large scale by Sir Oliver Lodge. Wires were strung on 15-foot poles equipped with high-tension insulators, and placed 30 feet apart over 19½ acres of ground. A dynamo driven by a 2-horsepower oil engine supplied 3 amperes at 220 volts, which was raised to 100,000 volts by an induction coil. It then passed through rectifiers, one pole of which was connected to the system of overhead wires and the other grounded. The leakage from these wires is said to have stimulated the plant growth so that crops of wheat, barley and strawberries showed an increase of from 25 to 35 per cent. The flour made from the wheat was of better quality, and sold at a higher price, as it contained a larger proportion of dry glutens and was better baking.—*The Journal of Electricity, Power and Gas.*

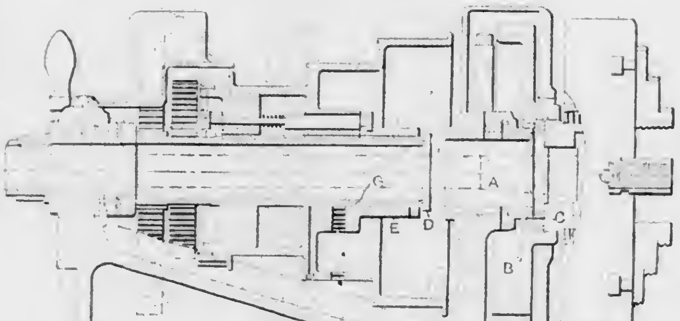
18-INCH CONE-HEAD ENGINE LATHE.

An 18 in. by 8 ft., cone-head, Schellenbach, engine lathe, made by The John B. Morris Foundry Company, Cincinnati, O., is illustrated herewith. It is of the same general design as the geared-head lathe, made by this company, except that the cone-head is used.

A sectional view of the headstock is shown on the drawing. The spindle A has a flange at its right end and receives the face gear B, which is dowled and screwed to it. This face gear B has internal threads and receives the face plate or the chuck. It will be seen that the chuck plate C fits the counterbore of the chuck and is bored to fit the end of the spindle and threaded on the outside to screw into the face gear B. Thus, when pressure is exerted against the chuck it clamps the flange of the spindle tightly between the chuck plate, C, and the face gear, B. This arrangement eliminates tortional strains within the spindle when running in back gear. Clutch teeth D are formed upon the spindle and engage the clutch E, which is splined to the cone pinion sleeve G. This clutch is operated at the back end of the headstock by a spring seated plunger which passes through the cone pulley. The plunger is provided with a knurl with a detent pin for holding it out of engagement.



SCHELLENBACH 18-INCH CONE-HEAD ENGINE LATHE.



CROSS-SECTION OF HEADSTOCK.

A three step cone is provided for a 2 in. double belt, the largest diameter being 12 in.; there are two changes of back gearing, making in all nine changes of speed with a single speed of the countershaft. The countershaft is provided with double friction pulleys, and where back motion is not needed it may be driven at two different speeds, thus giving the spindle six open belt speeds and twelve back gear speeds. The back gear is operated with an eccentric shaft in the ordinary manner. It will be noticed that the overhang of the chuck, from the face of the jaws to the front spindle bearing, is not as great as with the ordinary type of lathe. All gearing on the head is enclosed and is of coarse pitch.

A quick change device gives a range of threads from 2 to 112. A double plate apron and a special feature for rough chasing threads by the ordinary rack feed in place of the lead screw are provided, the object being to preserve the accuracy of the screw and to use it for only accurate chasing. A single wrench operates every adjusting screw throughout the machine, including the tightening of the tail-stock to the shears. The cabinet legs have hinged doors with latches operated by knobs. This lathe is also made in 14 and 16 in. sizes, and with a plain system of change gears, as well as with the quick change, as shown.

RAILROAD REPAIR SHOP ARRANGEMENT.

Certain fundamental principles should be recognized before attempting a railroad shop arrangement, and as far as possible the arrangement should be worked over until it satisfies these requirements, always recognizing exceptions due to individual conditions.

(1) Liberal space (say 100 per cent.) should be allowed for the extension of each department.

(2) The store house (with administrative offices in one of the upper floors) should be central, convenient to all departments, and easy of access on two tracks from the main line service track.

(3) The forge shop should be convenient to both the locomotive and car repair departments.

(4) The power house should be central and near the planing mill and repair tracks in order to burn refuse.

(5) Yard cranes should be arranged to serve between the store house platforms and all departments.

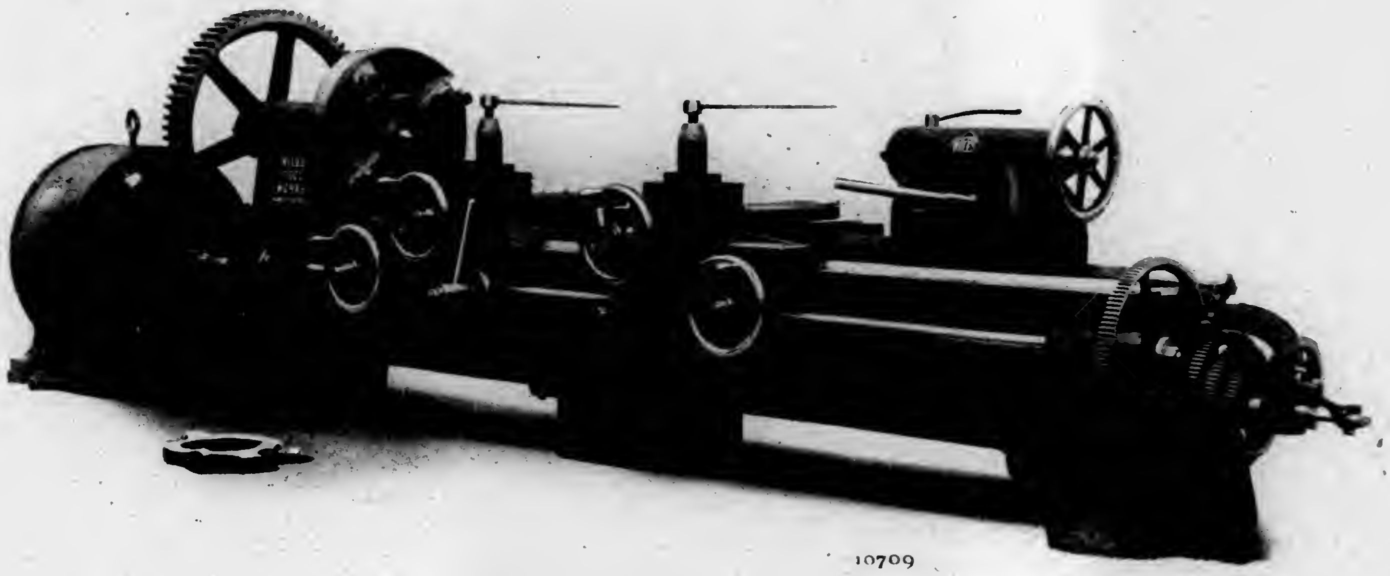
(6) The roundhouse should be very near the shop, or located far enough away to justify a separate machine shop for light repairs.

(7) Tracks, cranes, telphers, and storage spaces should be arranged to insure the movement of materials with the greatest economy of time and labor.

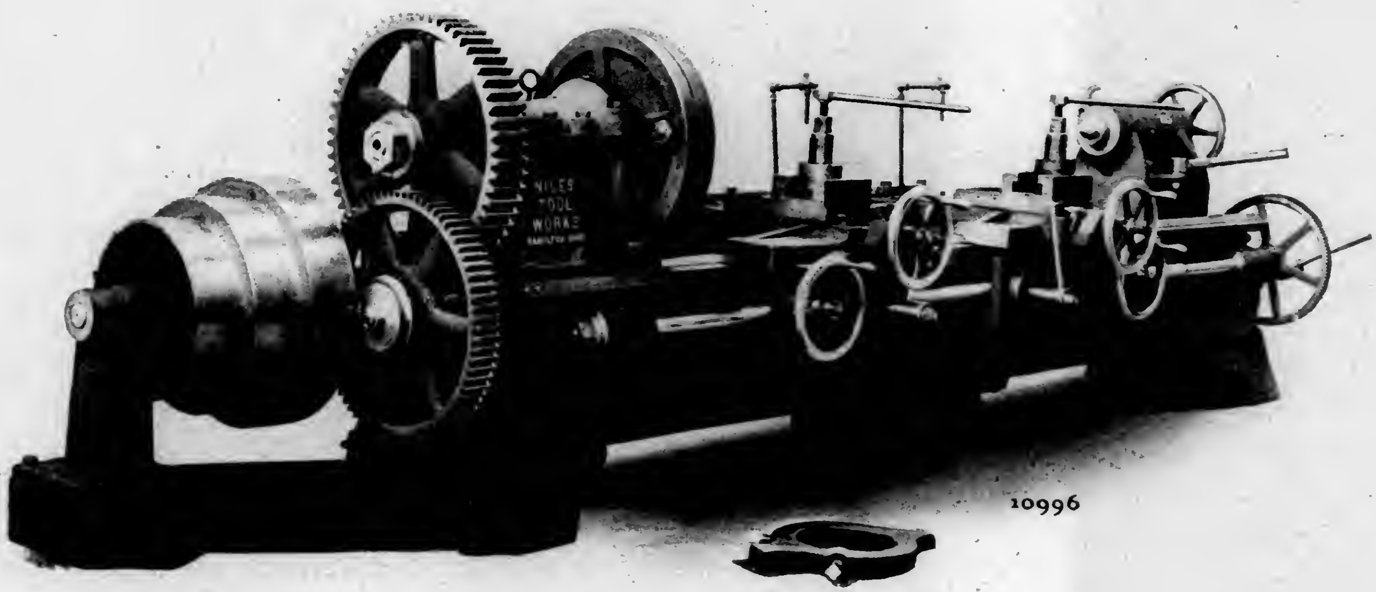
(8) Some consideration should be given to the appearance of the shops and accessory storage facilities, lumber yards, etc., from the main line.

(9) The advantages of a short tunnel of ample cross section for the use of the various steam air, and water piping systems should not be forgotten.

(10) The possibilities of the adoption of longer and heavier



NILES LOCOMOTIVE AXLE LATHE, MOTOR DRIVEN.



LOCOMOTIVE AXLE LATHE, NILES-BEMENT-POND COMPANY.

engines similar to the consolidation or articulated types should be considered, and some provision made for present or future repair facilities for these larger engines.

(11) The cost of the shops should be consistent with not only the actual necessities, but in proportion to the refinements which the road can afford. All expenditures over and above those required for actual needs should be capitalized and made to show a satisfactory return on the investment.—*George A. Damon before the Canadian Railway Club.*

LOCOMOTIVE AXLE LATHE.

The locomotive axle lathe, shown in the illustrations, is made at the Niles works of the Niles-Bement-Pond Co. and is of a very substantial design, intended for turning the heaviest driving axles. It has a swing of 14 in. over the carriage and a maximum distance between centers of 8 ft. The axle is driven by the double equalizing driver plate. The tail stock is of the usual form. The two carriages, right and left hand, are equipped with a positive power feed having three changes. Both carriages have opening nuts, quick hand movement and hand cross feed.

A pump keeps the lubricant in circulation, it being collected in a reservoir in the center leg of the machine. Brackets are placed at the back of the machine to which formers of any desired shape may be attached for giving the proper contour to the axle. Where desired a crane with a convenient hand hoist for lifting the axle in and out may be placed at the back of the bed. With the belt driven machine a 5½ in. belt is used; the lathe may be driven by a direct connected variable speed motor of 25 h.p. capacity, mounted on a plate attached to the bed as shown.

Electricity in Agriculture.—In England, electricity has been experimentally applied to agriculture on a large scale by Sir Oliver Lodge. Wires were strung on 15 foot poles equipped with high-tension insulators, and placed 30 feet apart over 10½ acres of ground. A dynamo driven by a 2-horsepower oil engine supplied 3 amperes at 220 volts, which was raised to 100,000 volts by an induction coil. It then passed through rectifiers, one pole of which was connected to the system of overhead wires and the other grounded. The leakage from these wires is said to have stimulated the plant growth so that crops of wheat, barley and strawberries showed an increase of from 25 to 35 per cent. The flour made from the wheat was of better quality, and sold at a higher price, as it contained a larger proportion of dry glutens and was better baking.—*The Journal of Electricity, Power and Gas.*

RAILROAD CLUB DOINGS

Canadian Railway Club.—Next meeting, Tuesday, October 6, at the Windsor Hotel, Montreal, Can. A. D. Thornton, general technical superintendent of the Canadian Rubber Company, will give an address on "Chemistry of Rubber," explaining in detail its use in the manufacture of rubber goods for mechanical purposes, more especially as applied to railroad use. The lecture will be illustrated with lantern slides.

R. E. Johnson in his paper on "Producer Gas Power Plants," presented at the September meeting, described a producer gas power plant of the suction type; presented some data as to the comparative cost of fuel for gas and steam power plants of 100 h.p. capacity; discussed the necessity of conserving our fuel supply; considered the difficulties which had retarded the more extensive introduction of producer gas and gas engine plants and directed attention to some important improvements which have been made in gas engine design and operation.

Secretary, James Powell, P. O. Box 7, St. Lambert, near Montreal.

Central Railway Club (Buffalo, N. Y.).—Next meeting, Friday, November 9. Secretary, H. D. Vought, 95 Liberty street, New York City.

New England Railroad Club (Boston, Mass.).—Next meeting, Tuesday, October 13. A paper on "Terminal Facilities for Handling Locomotives" will be presented by R. D. Smith, superintendent of motive power of the Boston & Albany Railroad. Secretary, G. H. Frazier, 10 Oliver street, Boston.

New York Railroad Club.—Next meeting, Friday, October 16. Raffe Emerson in his paper on "Better Service at Reduced Cost," at the September meeting, used the handling of locomotive supplies as an example of the results which may be accomplished by standardization and better supervision in improved service and reduced cost. His treatment of this question was in some respects similar to that of E. Fish Ensie in articles on the same subject in the January and March issues of this journal. In addition Mr. Emerson presented a number of lantern views showing similar results which had been obtained in other departments.

Secretary, H. D. Vought, 95 Liberty street, New York.

Railway Club of Pittsburg.—Next meeting, Friday, October 23. It has been practically decided to turn this into a "smoker." (*Business must be dull in the "smoky city."*)

C. W. Cross, superintendent of apprentices of the New York Central Lines, presented a paper on "Practical Results from a Modern Apprenticeship System" at the September meeting. The paper is unique because of the fact that it practically confines itself to the consideration of benefits of improved apprenticeship which are thus far apparent. It is surprising to note the importance of these, especially when we consider the comparatively short time in which this new system has been in operation on the New York Central Lines. A feature of the paper, which adds greatly to its value, is a bibliography consisting of a list of some of the more important articles on apprenticeship, which have been published during the past few years. This feature is commended to those who expect to prepare papers for railroad clubs and even in some cases to those who contribute articles to the technical press.

Secretary, J. D. Conway, P. & L. E. R. R., Pittsburg, Pa.

Richmond Railroad Club.—Next meeting, Monday, October 12. Alexander Kearney, assistant superintendent of motive power of the Norfolk & Western Railway, will talk to the club on "Boiler Tubes and the Beading of Tube Ends." The first meeting of the season was held on September 14th, at which time addresses were made by President W. H. White, of the R. F. & P. and the Washington Southern, and President Stevens, of the C. & O.

Secretary, F. O. Robinson, Richmond, Va.

St. Louis Railway Club.—Next meeting, Friday, October 9. Secretary, B. W. Frauenthal, St. Louis, Mo.

Western Railway Club (Chicago).—Next meeting, Tuesday, October 20. Secretary, J. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

Arthur Hale, general superintendent transportation, Baltimore & Ohio, and chairman of the committee on car efficiency of the American Railway Association, gave an interesting talk on "Progress Toward Car Efficiency" at the September meeting. He told of the work of the car efficiency committee and of the difficulties it had met with; also some of the things which it is trying to do at present.

Some Comments on the Railway Club Department.

To the Editor:

I am sure that a department for the discussion of the work done by the various railroad clubs would be an interesting feature for the American Engineer, and am glad to note that you think of trying it.

It occurs to me that possibly a very brief summary of the most important points brought out by the various papers and discussions would be valuable, particularly to such busy officials as do not have time to read the proceedings in full.

I think it would also be of much interest and assistance to many of the railroad clubs if you could present a list of suggestions for papers, as the question of obtaining live topics has been one of the most difficult for the Western Railway Club to handle to the satisfaction of its officers.

M. K. Barnum.

C. B. & Q. R. R., Chicago, Ill.

To the Editor:

In the September number of your very worthy paper the column entitled "What the Railroad Clubs Will Do in September," struck me as being a splendid move and one from which I anticipate being greatly benefited. I read your editorial after seeing the above mentioned title and I was glad to note that you intended making it a permanent item for each month, if you could secure the co-operation of the officers concerned, which I trust you will be able to do. It would be of much benefit to the membership of the various clubs to know what the others are doing and when a very able paper is presented in one club, the members of other clubs, by hearing of it through the column set aside for this particular purpose, would be enabled to know when to secure a copy of it.

I have found it very difficult, in trying to keep up with all that was being done in the various associations, to get a list of subjects, etc., but your proposed effort will be of much assistance to all those that want to know just what is being done in the various clubs.

L. W. Wallace.

Purdue University, Lafayette, Ind.

To the Editor:

I regard your new feature in announcing dates and topics of the various railroad clubs a very convenient and useful way of bringing this information to your readers. We can hardly be members of all of the railroad clubs, but at times would like very much to keep track of what some of them are doing, and to get this in the shape which you have put it is to my mind very desirable.

Some time when you are wanting a topic to enlarge on, would suggest advising the younger men to take advantage of railroad club opportunities for discussion. Many of these young men in course of time may be active in the associations and club train-

ing is invaluable as developing facility for easy speaking when on the floor and taking part in debate.

C. A. Seley.

Rock Island Lines, Chicago, Ill.

Editor's Note.*

Mr. Seley's suggestion is a splendid one. The railroad clubs can be used to considerable advantage by the ambitious young man, in assisting him to extend his acquaintance and to some extent to show his associates and superiors the kind of stuff he is made of. Many motive power officials can show how taking part in the work of the railroad clubs, or writing for the technical press, has been the direct means of assisting them to secure advancement.

A young man should never attempt to take part in a railroad club discussion on the spur of the moment, unless he is thoroughly familiar with the subject. It must be remembered that while it is possible to create a favorable impression by good logic, clear cut expression and evidence of a thorough knowledge of the subject under discussion, it is just as much of a disadvantage if the subject is not handled properly.

It is always advisable to prepare a written discussion beforehand. This may be read, although, if possible, it is better to use such notes as a guide and to speak extemporaneously. The advantage of writing the discussion beforehand is that it crystallizes the subject in one's mind. No matter how simple a piece of work you may perform if you attempt to write a description of it you usually find that you have yet much to learn concerning it, and often are led to see where you could make a great improvement.

In this connection the suggestion might be made that the club secretaries should try to issue the advance papers as much as possible in advance of the time of meeting. Under present conditions, in some of the clubs, the advance papers are received so late that it is almost impossible to give the proper amount of time to studying them before the meeting. The result might be not only to make it possible to have the young men take part more generally, but some of the older members would come to the meeting with a clearer idea of the subject under discussion and would not waste the time of the club by talking to cross purposes. At same time it would make it possible for the speaker of the evening to present the subject in brief abstract, allowing more time for a thorough discussion.

Rapid Ore Handling.—There are four machines at Cleveland, Ohio, for unloading ore vessels which can accurately weigh and deliver a car load of ore from vessel to car in about seven seconds.

Evening Classes at Columbia.—Columbia University will, during the fall and winter, offer twenty evening courses especially adapted to the needs of technical and professional workers. These include work in applied mechanics, applied physics, architecture, electricity, fine arts, industrial chemistry, mathematics and surveying and structures. The work will begin on October 26 and will continue for twenty-five weeks. A full description of the courses is contained in the "announcement of extension teaching," which may be obtained on application to the director of extension teaching, Columbia University, New York City.

Total Power Used in United States.—Using the data furnished by the census returns of 1900, 1902, and 1905 as a basis and applying the prevailing rate of increase in the industries included in these reports, and adding an equivalent amount for the steam railroads, it is estimated that the total installed capacity of prime movers in all our land industries for the year 1908 approximates 30,000,000 h.p. The average load on steam and other engines is much less than their rated capacity, and, owing to the overlapping of loads, it it probable that the total average load does not exceed one-third or one-quarter of this amount.—*H. St. Clair Putnam at the Conference on Natural Resources.*

* See also December, 1907, issue, page 473.

SUGGESTIONS AS TO AN IMPROVED SYSTEM OF BILLING FOR REPAIRS UNDER M. C. B. RULES.

To the Editor:

Referring to a suggestion which has been made looking toward doing away with the complicated system of billing for repairs under the M. C. B. rules by billing for repairs at an average cost per mile, or per day, as the rental is billed for. There seems to me to be serious objections to this. In the first place, it might be difficult to arrive at a rate per mile, or per day, which would be satisfactory to all the interests concerned.

Presuming that this difficulty was overcome there would remain the seemingly unanswerable objection that such an arrangement would inevitably lead to a neglect of equipment; it would be to every one's interest to get rid of cars with existing defects rather than to repair them. At the present time, I believe that under the M. C. B. rules, while it is not probable that any road can make any money by repairing foreign cars, yet in most cases there would be such a small loss that in general the tendency is to repair all defects as soon as possible after their happening. This is a factor which must be considered as of great value. Under the proposed change of the rules, the general tendency would be to try to dispose of cars to connecting lines with all the existing defects they could be made to stand for. This would not seem to be a desirable state of affairs.

There is another way of doing away with all the expensive routine of billing for car repairs, and while there are serious objections to it, it seems to me that it would dispense with a great deal of the red tape of the present rules without the attendant difficulty of tending to prevent a general habit of keeping foreign cars in a reasonably good state of repairs. My idea would take us back to the old rules, and about as far beyond them as the present rules are developed on the side of the owner being responsible for all except wreck damage; for although the rules make a good many exceptions beside actual wreck damage, it is altogether probable that there are "adjustments" which manage to throw almost all defects into the "owner's" class unless they are so serious as to be beyond question due to a wreck.

Now, if the rules should be changed so as to make the delivering company responsible for all defects on a car, matters would then be in a condition where the road which was handling the car would prefer to make the necessary repairs rather than to give its defect card to the connecting road when the car was offered in interchange, and the road receiving a car carrying a defect card would be likely to repair that car at the expense of the delivering road, rather than let the defect continue, with the probability of causing further damage for which it would be responsible.

The most patent objection to this method would be the fact that at present prices it would be in many cases to the advantage of the delivering road to issue its defect card because at present M. C. B. prices it would be probably cheaper to depute the work to some one else rather than to do it themselves. My plan would therefore involve the increasing of the M. C. B. prices to such a level that there would be a profit of 15 or 25 per cent. to the road which made repairs under the rules, on the authority of a defect card. It would then be to the advantage of the delivering road to make the repairs itself, except under special circumstances, and then the road which did the work would profit at the expense of the road which did not repair the defects for which it was responsible.

A feature of this plan would be that roads which borrowed more equipment than they loaned would probably be at a disadvantage, while roads whose borrowing did not exceed their loaning would break even; roads which were loaning more than they borrowed would probably be at somewhat of an advantage, as compared with present practice, and this would not seem to be an undesirable feature.

The only serious disadvantage that I can see in this plan is that there might be a tendency on the part of car owners to neglect the condition of their own equipment, but since they would be responsible to a road to which they should deliver a

car for the defects then existing, it seems that this would correct any tendency in that direction. This is directly in opposition to the present practice under the M. C. B. rules; and I will admit that it would be a pretty drastic change: but it seems that some radical change is about due.

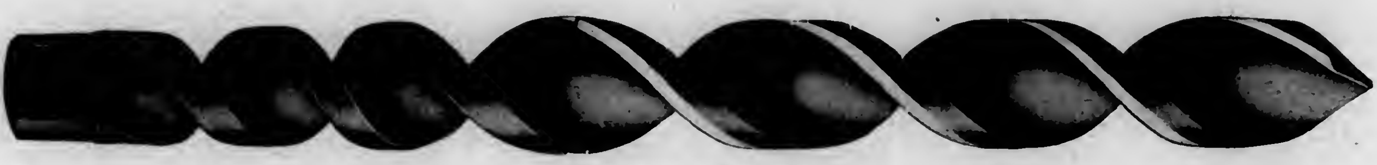
The constant petty changes in the M. C. B. rules, and the innumerable petty and sometimes important questions which are brought up for settlement by the arbitration committee, are leading to the place where it will be practically impossible for a man of not above the general average of intelligence, from the ranks of whom our repairmen and inspectors must be drawn, to devote enough attention to the study of the rules and the arbitration decisions, which supplement and sometimes appear to be at variance with the reading of the rules themselves, and to, at the same time, be a competent "practical" man, able to handle successfully the actual work on the cars.

This tendency is toward greater efficiency, for it is a well tried out principle that greatest efficiency is attained by greatest specialization; but it is not reasonable to expect men to be equally well versed in more than one specialty. I believe that we could expect much more effective and economical work from our inspectors and repairmen if they were relieved of the making of repair cards and all the details which of necessity accompany that work.

I think every one connected with the making of car repair bills, and with their checking when received by the home road, would be interested in a discussion of some rational method of doing away with the work under the M. C. B. rules; which work is gradually, but surely, working toward that undesirable stage popularly known as "red tape." A. M. ORR.

Greenville, Pa.

(PATENTED)



HACKETT HIGH SPEED DRILL.

HACKETT HIGH SPEED DRILL.

The Hackett high speed drill is twisted from specially finished bars of high speed steel. The twist, as may be seen from the illustration, extends from the point of the drill to the tang and the shank is therefore of a skeletonized cylindrical form. It is claimed that this design saves 50 per cent. in the weight of the steel used, as compared to an ordinary twist drill. The only machining required is to clean a few ounces of material off the edge of the blank from which the drill is twisted, leaving the skin of the greater part of the forging intact. The dangerous temperature strains, which are responsible for the breakage of so many high speed drills, are practically eliminated because of the uniform section of the drill.

As practically all drill presses, air motors, ratchets, turning and boring machines are equipped for the use of Morse taper shanks it was recognized that the new drill should, if possible, meet these requirements; not only does the skeletonized shank meet all the requirements of the solid taper shank, but it possesses some additional advantages. The principal advantages of the solid taper shank are that a perfect alignment is secured and it permits ease of insertion and removal. The latter point is especially important when it is considered that a high speed drill requires only about fifteen seconds to drill an inch in depth. Changing the drill, even under the most favorable circumstances, may therefore often require several hundred per cent. more time than the actual drilling.

The skeletonized design diffuses the tough, specially hammered surface of the material into the general structure, thus increasing it in stiffness and strength. This design of shank does not allow the strains to become localized, but permits the drill to bend in a manner not unlike a leaf spring, thus preventing the possibility of crystallization, which is the result of local vibrations. The metal in the shank is softer than the rest of the drill and the corkscrew action has a tendency to force it more tightly into its socket, thereby securing a firm fit; there is not the possibility of a loose fit such as sometimes occurs with solid taper shanks which are slightly defective and which often throw all the strain on the tang, twisting it off.

The combination of a tightly fitting shank and a tang of high speed steel of great strength practically eliminates twisting off this portion of the drill with the resultant chewing up of the socket. These drills are manufactured by the Hackett High Speed Drill Company, 90 West street, New York. The drill was designed and patented by George E. Hackett, who was for some time connected with the mechanical engineering department of the Central Railroad of New Jersey, and who has spent three years in developing and testing the drill.

BURNING SHAVINGS IN POWER PLANTS.

With modern coal handling machinery, including mechanical grates and overhead coal bunkers, it is a question whether the shavings are not more bother than they are worth, and we have known cases where it was cheaper to burn coal than to go to the expense of cutting up the old car sills. The planing mill is, and always will be, an inflammable building. The contents are exceedingly liable to catch on fire, and even if the building was fireproof there could be sufficient heat generated by the burning contents of the planing-mill to ruin it. This being the case, if it is in close proximity to the power house, the most important building of the whole outfit would be endangered, and this is rendered still more critical by the fact that the fire pumps for fighting the very fire which is dreaded are generally located in the power house, and this would be endangered by its proximity to the planing mill.

The constant speed of tools, which is a characteristic of all woodworking machinery, lends itself particularly to the use of alternating current motors whose non-commutation (and corresponding sparklessness) is particularly valuable in an atmosphere full of sawdust. Alternating current can be distributed at great distances with satisfactory economy, and permits placing this dangerous fire risk at a safe distance from the central power house, and this advantage should not be overlooked. There can be plenty of use made of the shavings from the planing mill by locating a small boiler near by and allowing this to provide steam for the dry kiln, and in the winter time also for heating the planing mill. This will dispose of the troublesome question of handling the shavings, and yet will keep the woodworking department away from the most important building in the whole outfit.—*G. R. Henderson, Canadian Railway Club.*

THE LARGEST HYDRAULIC DREDGE.—The Russian Government has recently received the most powerful dredge ever constructed. It was designed by Lindon W. Bates of New York and all of the electrical equipment was furnished by the General Electric Co. It was built at the Liege Works of the Societé John Cockerill. The dredge is in two parts, each half being 216 ft. long, 31½ ft. wide and having a light draught of 4 ft. It is electrically controlled and propelled, each half having a 600 kw. generator driven by a quadruple expansion engine. The whole dredge has a capacity of 7,000 cu. yds. hourly in favorable material. This gives a capacity of 2,000,000 cu. yds. monthly working 10 hours a day.

PERSONALS.

W. M. Saxton has been appointed locomotive foreman of the Grand Trunk Pacific Ry. at Bigger, Sask.

B. J. Peasley has been appointed master mechanic of the Missouri Pacific Ry. at Ferriday, La., succeeding J. Schumacher, transferred.

A. H. Gairns has been appointed master mechanic of the Oregon Short Line at Pocatello, Idaho, succeeding Henry Carrick, assigned to other duties.

E. F. Jones has been appointed acting master mechanic of the Chicago & Western Indiana R. R., in place of P. H. Peck, who has been granted a leave of absence.

C. B. Williams has been appointed general storekeeper of the Central R. R. of New Jersey, with office at Elizabethport, N. J., succeeding W. F. Girten, resigned.

Charles H. Osborn has been appointed assistant superintendent of the car department of the Chicago & Northwestern Ry., with headquarters at the Chicago shops.

J. J. Sullivan, master mechanic of the Louisville & Nashville Ry. at Louisville, Ky., has been transferred as master mechanic to New Decatur, Ala., succeeding H. C. May.

H. C. May, master mechanic of the Louisville & Nashville Ry. at New Decatur, Ala., has been transferred as master mechanic at South Louisville, succeeding W. L. Tracy, resigned.

G. W. Taylor, master mechanic of the Atchison, Topeka & Santa Fé Ry. at Newton, Kan., has been appointed superintendent of motive power of the San Antonio & Aransas Pass Ry., with headquarters at San Antonio, Texas.

George Wagstaff, formerly supervisor of boilers of the New York Central Lines, has entered the service of the American Locomotive Equipment Co., instead of the Railway Materials Co., as announced in the previous issue.

W. L. Tracy, formerly division master mechanic of the Louisville & Nashville Ry. at South Louisville, Ky., has been appointed assistant superintendent of machinery of the Missouri Pacific Ry., with headquarters at Kansas City, Mo.

David Patterson has been appointed master mechanic of the Kansas & Oklahoma division of the Kansas City, Mexico & Orient Ry., and J. S. Hardie has been appointed general foreman of the car department, both with headquarters at Fairview, Okla.

Frank Howard has resigned as general foreman of the car department on the Eastern division of the Wabash R. R. Mr. Howard began railroad work in 1869 on the Missouri, Kansas & Texas Ry., and has been at the head of the car department of the Wabash since 1885.

Peter H. Peck, past president of the American Railway Master Mechanics' Association, member of the arbitration committee, M. C. B. Association, and past president and treasurer of the Western Railway Club, has received a leave of absence from his position as master mechanic of the Chicago & Western Indiana Ry., which practically terminates a term of twenty-one years service with that company.

G. E. Carson, master car builder of the Pittsburg & Lake Erie R. R., at McKees Rocks, Pa., has resigned, to take a similar position with the New York Central & Hudson River R. R., at West Albany, N. Y. Mr. Carson is succeeded by Mr. Samuel Lynn, at present car foreman.

Charles J. D. Donahoe, for many years identified with the motive power department of the Lake Shore & Michigan Southern Ry., and since then secretary to the vice-president of the New York Central Lines at Chicago, has resigned to become secretary to W. H. Marshall, president of the American Locomotive Co.

Adam Bardsley, until recently general master mechanic of the Gulf & Ship Island Railroad, died at his home in Bradford, Pa., on August 19. Mr. Bardsley was a native of England, and began his railroad career in this country in 1873. He occupied successively the positions of master mechanic on the Northern Pacific R. R., master mechanic on the Buffalo, Rochester & Pittsburgh R. R., traveling representative of the American Locomotive Company and general master mechanic of the Gulf & Ship Island R. R. Deceased was sixty years of age.

BOOKS.

American Railway Engineering & Maintenance of Way Association.—Proceedings of the ninth annual convention. Published under the direction of the committee on publications. W. D. Pence, editor, Madison, Wis.

This volume of proceedings includes the complete reports and discussions thereon at the convention held in Chicago last March. In addition to reports there are included the personnel of the different committees, copy of the constitution and by-laws and a list of the members of the association.

How to Build Up Furnace Efficiency. By Joseph W. Hays. Pamphlet size. 44 pages. Published by the author, 601 Hartford Bldg., Chicago, Ill. Price, 50 cents.

The subject of gas analysis and its practical value are not generally understood or appreciated by operating engineers. The author of this pamphlet, who is a practical combustion engineer and has published a number of works on furnace efficiency, recognized this condition and has attempted to fill the void in a very practical treatise, which will be within easy comprehension of the ordinary operating engineer and lead him to improve his furnace efficiency in a scientific manner.

Universal Directory of Railway Officials. 1908 edition. Compiled under the direction of S. Richardson Blundstone, editor of the *Railway Engineer*. Published by the Directory Publishing Company, Ltd., 3 Ludgate Circus Buildings, E. C., London. United States representative, A. Fenton Walker, 143 Liberty street, New York. Price, 10 shillings ($2.50).

This directory is the most complete and valuable work of its kind and presents complete information as to the length of line, gauge, number of locomotives and cars, as well as a directory of all of the officers of every steam railroad in the world. The street railways of the United Kingdom are also included.

CATALOGS

IN WRITING FOR THESE PLEASE MENTION THIS JOURNAL.

"The Way to Forget" is the title of a very interesting story being issued by the Triumph Electric Company, Baymiller and Sixth streets, Cincinnati.

Giant Talks.—The Coburn Trolley Track Mfg. Co., of Holyoke, Mass., publishes monthly a small magazine having the above title. The reading matter carries a conversational tone and serves to illustrate the advantages of this type of trolley track.

Metal Weather Strips.—The Frost Railway Supply Company, Penobscot Bldg., Detroit, is issuing a small booklet illustrating and describing metal weather strips for railway coaches. These strips keep the dust out of the car and absolutely prevent the windows from rattling.

Revolving Steam Shovels.—The Browning Manufacturing Co., Mansfield, O., is issuing a catalog devoted chiefly to illustrations showing the Browning standard steam shovels of the revolving type, which are light in weight and have a very large radius of action. They can also be used as locomotive cranes if desired.

HYDRAULIC PUMPS.—Dean Bros. Steam Pump Works, Indianapolis, Ind., is issuing catalog No. 71, which contains about 40 pages of descriptive matter and illustrations showing hydraulic pumps for all purposes. These pumps can be furnished to deliver pressures as high as 8,000 lbs. per sq. in. Vacuum and compressed air pumps are also being manufactured by this company and are shown in this catalog.

TRIGONOMETRIC SLIDE RULE.—M. J. Eichhorn, electrical engineer, 5759 Aberdeen street, Chicago, has devised a new type of slide rule, which is intended to supplement the present types of rules and has special use in the matter of the solution of triangles, being provided with new graduations for that purpose. A leaflet is being issued giving the principles upon which this rule is based and can be obtained by any one interested.

AUTOGENOUS WELDING.—The Davis-Bournonville Co., West Street Building, New York, is issuing an illustrated catalog on the subject of oxy-acetylene welding and cutting apparatus. The catalog describes in detail the process of cutting and welding, as well as the apparatus in which the gases are generated and combined. Tables of the cost for welding sheets from 1/32 to ½ in. and over and for cutting sheets over 1½ in. are included.

CHICAGO PNEUMATIC DRILL CO.—The advance sheets of Catalog No. 26, covering the section devoted to the Franklin air compressor, is being issued by this company from its general offices in the Fisher Bldg., Chicago. This type of compressor, introduced about eight years ago, has become very popular and new styles and sizes are constantly being added as demand arises for them. The present catalog covers about 100 different styles and sizes.

NEW WESTON ELECTRIC INSTRUMENTS.—The Weston Electric Instrument Co., Newark, N. J., is issuing a small leaflet containing a brief preliminary description of new instruments which are now being put on the market. These consist of a new switchboard alternating current ammeter and voltmeter, new portable alternating current ammeter and voltmeter and a new direct current switchboard instrument. The catalog gives the sizes and prices at which each one of these instruments can be furnished.

INDICATORS.—The American Steam Gauge & Valve Mfg. Co., Boston, Mass., is issuing a new catalog on the subject of the American Thompson improved indicator. The catalog is very complete, showing a variety of designs of this type of indicator and also a complete line of attachments and instruments for use in connection with indicators. Full instructions are given for the proper method of taking care of these instruments, attaching them to the engines and how to make diagrams. A number of pages are also devoted to extracts from Hill's Manual on the benefits to be derived from the information ascertained by the use of indicators.

ELECTRICAL MACHINERY.—One of the publications issued by the General Electric Company, Schenectady, N. Y., during the past month is bulletin No. 4617, covering the subject of small size direct connected generating sets. These are driven with steam engines and are furnished in sizes from 2½ to 75 kw. Another publication, which is given the number of 3687, gives a brief history of the material used in transformer construction and is entitled "Transformer Steel." Bulletin No. 4612, which will be of interest to owners of electric automobiles, illustrates and describes a combination ammeter and voltmeter specially designed for that service.

GENERATORS AND MOTORS.—The Northern Electric Mfg. Co., Madison, Wis., is issuing a couple of new bulletins, one devoted to type L engine driven generators, which is numbered 55, and has been compiled to set forth engineering facts in a concise manner and also contains electrical information of a general character that is very interesting. Bulletin No. 56 is on the subject of belted motors and generators which have been on the market for some time and are furnished in a range of sizes and speeds to meet the ordinary requirements. A number of small leaflets are also being issued, among which might be mentioned No. 154 on electric emery grinders.

ELECTRIC MOTOR AND TRAILER TRUCKS.—A pamphlet just issued by the American Locomotive Company, which besides being a catalog of the different designs and types of electric motor, locomotive and trailer trucks for all classes of service, manufactured by the company, contains considerable useful data on electric railway equipment, making it a valuable book of reference for general managers, master mechanics and engineers.

The pamphlet contains 114 pages, the first 57 of which are devoted to illustrations and descriptions of the different standard and special types of electric trucks built by the company. The descriptive matter gives briefly the characteristic features of each different type and in the majority of instances each truck is illustrated by reproductions from photographs showing the side and perspective views and also by an assembled drawing giving the principal dimensions, weights and other important data. Then follow illustrations of a few cars equipped with the company's trucks, the principal data for the car illustrated being given under each view. The remainder of the pamphlet is devoted to illustrations and data, conveniently arranged, on electric railway equipment. In this chapter are included the standards adopted by the American Street & Interurban Railway Engineering Association; illustrations together with tables of weights of different makes of electric truck journal boxes; illustrations and table of capacities of ball-bearing center and side bearings for electric trucks; illustrations showing different styles of tire fastenings, sections and tables of weights of cast iron, steel tired, rolled steel and solid forged truck wheels; principal dimensions of street railway motors manufactured by the General Electric Company and Westinghouse Electric & Manufacturing Company; data on air brake equipment manufactured by General Electric Company, Westinghouse Traction Brake Company and National Brake & Electric Company; a table of data relative to standard car equipment of electric railways in the United States and Canada; a table of location of third rails; a list of names of the parts of an interurban combination passenger and baggage car manufactured by the Jewett Car Company; a table of dimensions and weights of car bodies manufactured by the Cincinnati Car Company; a list of names of all parts of the American Locomotive Company's standard Type A high speed truck and material specifications.

NOTES.

CROCKER-WHEELER COMPANY.—A new office of this company has been opened in the Gumbel Building, Kansas City, Mo. It will be in charge of A. W. Payne.

WM. J. SMITH & CO.—Messrs. Fred Ward & Son, First and Howard streets, San Francisco, Cal., have been appointed Pacific coast agents of the above company, whose main office is in New Haven, Conn.

LATROBE STEEL COUPLER CO.—John Havron has resigned as president of the Rogers Locomotive Works to take a position as western representative of the above company. His office will be in the Old Colony Building, Chicago.

BALDWIN LOCOMOTIVE WORKS.—Lawford H. Fry, technical representative of the Baldwin Locomotive Works in Europe, is transferring his headquarters from London to Paris, where he is opening an office at 56 Boulevard Haussmann.

AMERICAN SPECIALTY COMPANY.—H. L. Mills, formerly in the sales department of the Whiting Foundry Equipment Company, has resigned to accept the presidency of the American Specialty Company, 1440 Monadnock Bldg., Chicago, which is marketing the "Use-Em-Up" drill sockets.

S. F. BOWSER & CO.—Frank T. Hyndman, formerly mechanical superintendent of the N. Y., N. H. & H. R. R., has been appointed eastern railroad representative of the above company. Mr. Hyndman takes the place of Wm. A. Pitcher, who met his death in the Aveline Hotel fire at Fort Wayne, Ind., last May.

BETTENDORF AXLE COMPANY.—This company announces that its rapidly increasing business is compelling an extension of its plant and machinery equipment at Bettendorf, a suburb of Davenport, Ia. Several years ago it obtained sufficient space to enable it to manufacture all classes of railway equipment, including the building of complete railway cars.

CUTLER-HAMMER MFG. CO.—Announcement is made by the National Battery Company, of Buffalo, that the receivership under which it has been operating since last November was terminated on August 19. The full control of the reorganized company has been secured by the Cutler-Hammer Mfg. Co. of Milwaukee, Wis. The plant in Buffalo will continue to be operated as heretofore.

LOCOMOTIVE APPLIANCE COMPANY.—At the first regular meeting of the board of directors of the above company the following officers were elected: C. A. Thompson, president; Ira B. Kegler, 1st vice-president; H. S. Gray, 2nd vice-president; Willis C. Squire, 3rd vice-president and treasurer; W. H. England, secretary and assistant treasurer, and E. H. Allfree, mechanical engineer.

ANNUAL REPORT OF THE AMERICAN LOCOMOTIVE COMPANY.—The seventh annual report of the directors of the American Locomotive Company, which gives the financial condition of the company for the year ending June 30, 1908, is being issued. It shows that there was a decrease of over twelve million dollars in the gross and over one and three-quarter million dollars in the net earnings of the company for the year.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—The season of professional meetings of the A. S. M. E. will be opened on Tuesday evening, October 13, by a meeting of the Gas Power section in the Engineering Societies Building, New York. Two papers will be read, one by E. A. Harvey on "Gas Producer Plants," containing data of costs, performances, etc., and one by N. T. Harrington, giving results of tests of producer plants.

ADREON MFG. CO.—This company, whose home office will be in the Security Building, St. Louis, and Chicago office at 300 Western Union Building, has been organized for the purpose of manufacturing and selling railway supplies. It will represent in the southwest the following companies: American Brake Shoe & Foundry Company; Steel Car Forge Company; Pittsburgh Lamp Brass & Glass Company; Acme Pipe Clamp Co., and will also manufacture on its own account several railway specialties. The organizers of this company are E. L. Adreon, Jr., D. R. Neiderlander and Wm. Miller.

STANDARD FIFTY TON GONDOLA COAL CAR.

VIRGINIAN RAILWAY.

The Virginian Railway extends from the coal fields of West Virginia to tidewater and has been constructed throughout with the idea of hauling trains of very heavy tonnage. The rated train load over the line will be 80 loaded cars or about 6,000 tons behind the locomotive. This road differs from most other American railways in the fact that there will be comparatively little interchange traffic and the equipment can be designed for the service desired with the assurance that it will always be available. This service, in the case of the coal cars, will be very severe, for, in addition to the heavy rated train load, the unloading will be by Hewlett unloading machines, in which the car is clamped in a framework and turned over bodily. This is severe treatment and cars to stand up under it must be specially designed with this service in view. It is with all of these points in mind that the car illustrated herewith has been designed. The designer was not hampered by restriction as to clearance or rules of other systems and has developed a construction which in many respects is novel and admirable.

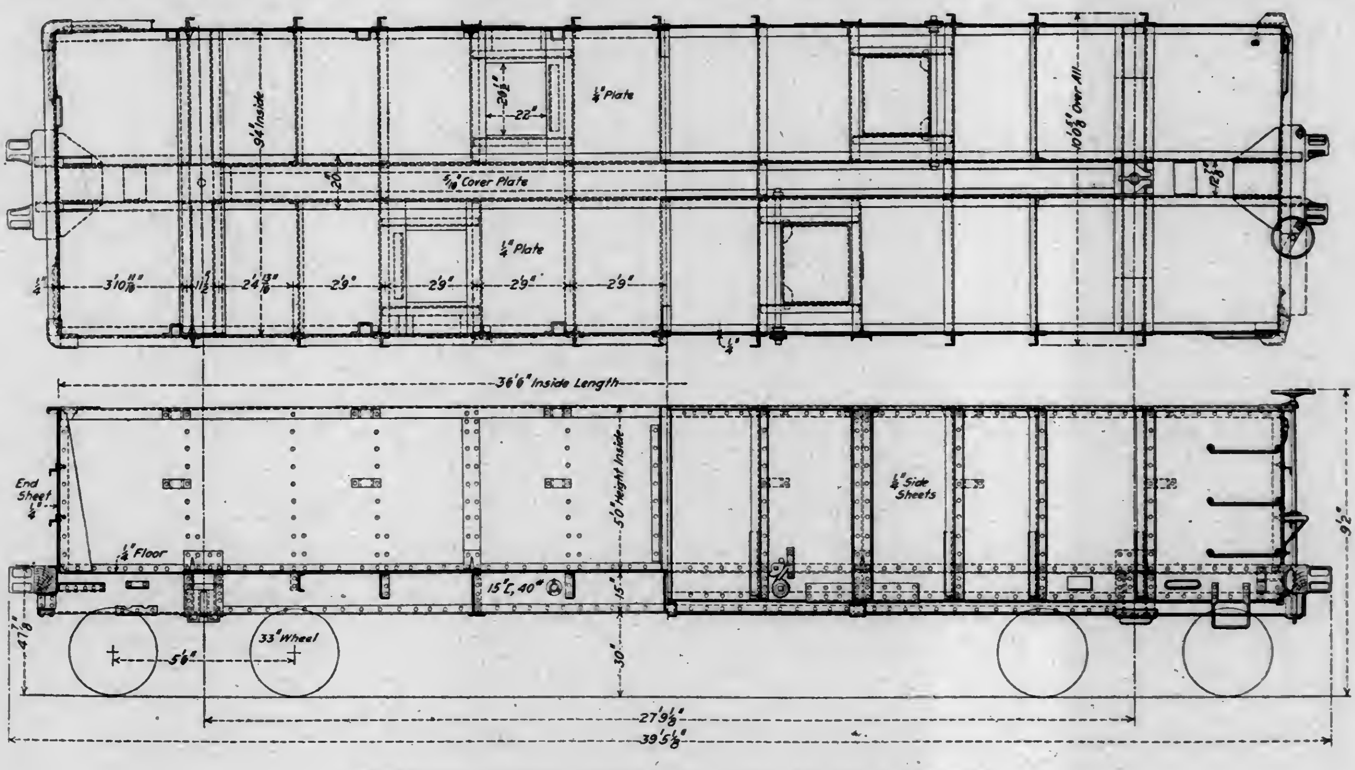
Although the unloading is normally to be done by machines it was deemed advisable to furnish four small bottom doors, which close flush with the floor, for use on the ordinary type of coal pockets. These doors are arranged two on either side and staggered as shown in the plan.

Considering the details of the design, and referring to the accompanying illustrations, it will be seen that the center sills consist of two 15 in., 40 lb., channels set back to back, about 13 in. apart and extending continuous for the full length of the car. These are reinforced between the bolsters by a 3½ x 3 in., 6.6 lb., angle riveted opposite the lower flanges and a 20 x 5/16 in. top cover plate also extending between the bolsters. The side sills consist of a 10 in. built up channel, the web of which is formed by the extension of the ¼ in. side plates, the lower flange by a 3 x 3½ in., 6.6 lb., angle and the upper flange by the ¼ in. floor plate, which is flanged upward 2⅞ in. and riveted to the side sheets. This built up structure is stiffened by the side posts which extend to the bottom of the side sheets, being spaced about 2 ft. 9 in. apart.

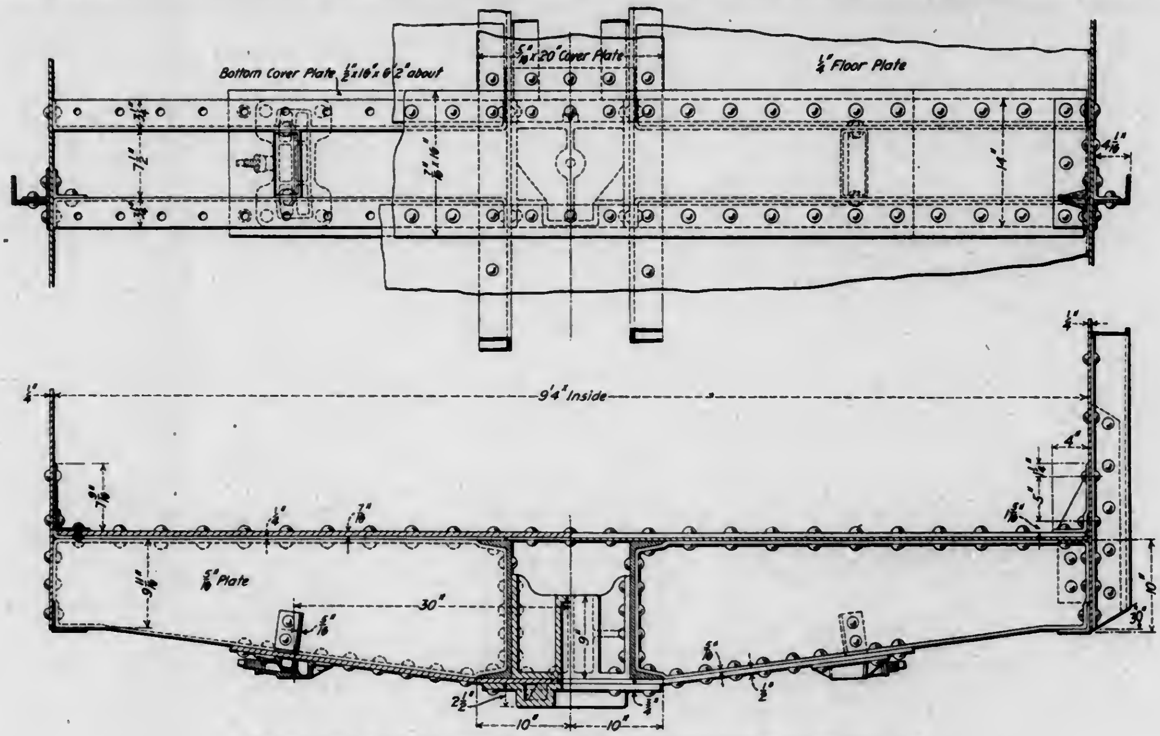
The body bolster consists of two diaphragms on each side of the center sills, set back to back, each formed of a 5/16 in. plate with a flange 3¼ in. wide all the way around. These diaphragms are flanged to fit the center and side sills to which they are securely riveted. The cover plate consists of the ¼ in. floor plate and a 7/16 x 16 in. plate above this, both of which are securely riveted to the flanges of the diaphragms. There is a ½ x 16 in. bottom cover plate extending continuous below the center sills to a point just beyond the side bearings. A cast steel center casting fits between the center sills and is held by four of the same rivets securing each diaphragm to the sills. A flanged 5/16 in. plate, 4½ in. deep, forms a backing and stiffener between the diaphragms just above the side bearings.

Between the bolsters there are three single deep diaphragms, between the side and center sills on each side of the same size and shape as at the bolster; also four flanged intermediate cross bearers and two channel iron cross bearers. The construction at the deep diaphragm cross bearers is the same as at the bolster, except that there is no cover plate at the top, the diaphragm simply being riveted to the floor sheets and no filling piece between the center sills. The shallow diaphragms, which are shown in one of the details, are flanged in the same way as the deep ones to fit around the side sills and to the upper part of the center sills. There are flanged filling pieces between the center sills at these points. The two channel iron cross bearers are located nearest to the bolster and consist simply of 6 in., 8 lb., channels secured with angle irons to the side and center sills and riveted to the floor sheet.

The side posts are of 4 in., 10.3 lb., Z bars, reinforced by a 3 x 3½ in. angle for about 2 ft. up from the bottom. The side sheets, of ¼ in. steel, are in three sections on each side, the join being covered by a 7 in., 12¼ lb., channel, which takes the place of the side post at these points. The channel side posts come opposite the deep diaphragm cross bearers. The sides are 5 ft. high inside and are capped with a special shaped bulb angle, a section of which is shown in one of the illustrations. At the corners angle irons form the posts and the end and side bulb



FIFTY-TON STANDARD GONDOLA COAL CAR—VIRGINIAN RAILWAY.

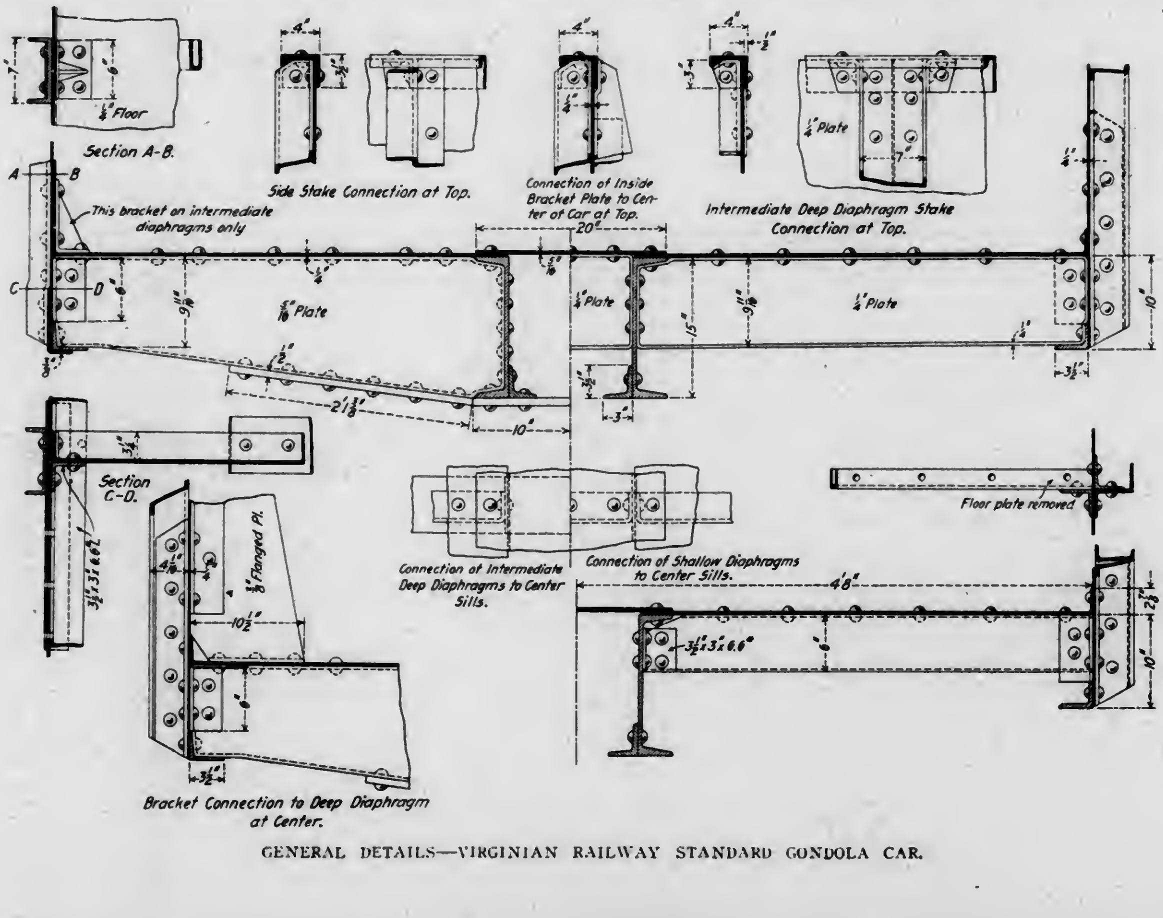


DETAIL OF BOLSTER—VIRGINIAN RAILWAY STANDARD GONDOLA CAR.

angles are connected by a casting. Inside the body at the center post is a stiffener formed of a ⅜ in. flanged steel plate which has a bearing of 10½ in. at the bottom and extends nearly to the top of the sides. Pockets are secured on the inside, opposite the posts, for the insertion of stakes when the car is used for carrying lumber.

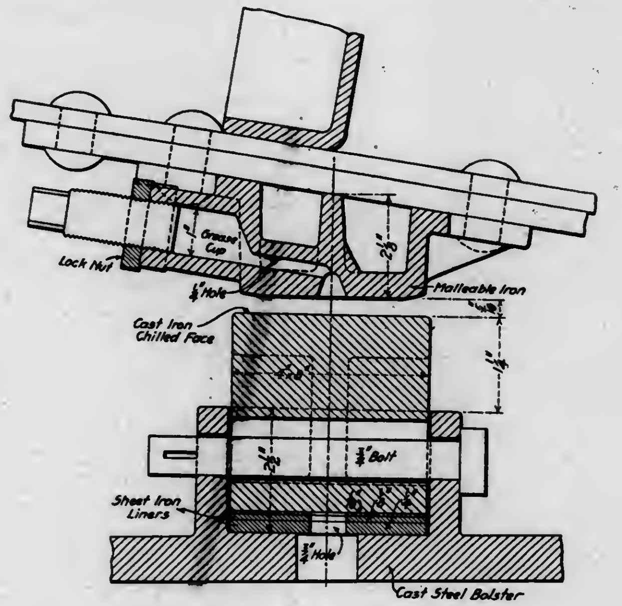
The end construction consists of ¼ in. plates stiffened by two horizontal Z bars and by vertical stiffeners on the inside, one over each center sill, of the same shape and construction as is used in the center of the side sheets.

The most careful attention has been given in this car to the matter of draft rigging and its attachments. The details at this point are shown in one of the illustrations and it will be seen that the end sill, which consists of a 10 in. channel, extends nearly 3 in. above the floor level and is secured to the flanged edge of the ¼ in. floor sheet as well as the end sheet. The center sill is cut away to clear the end sill, which gives a clearance of 7⅞ in. above the bottom of the center sill for the passage of the coupler shank. A pressed steel gusset plate fits between the center sills and backs up the lower edge of the end sill and similar plates are provided outside of the center sills, extending nearly to the end of the wooden buffing block. A ½ x 7 in. sheet is pressed into a U shape and fits between the center sills at the end stiffening them and forming a support for the wooden buffing block. Since the type of draft gear has not yet been decided upon, the location and construction of the follower stop castings are not given. The construction is such as to give the coupler a 1¾ in. side clearance at the end of the pocket.



GENERAL DETAILS—VIRGINIAN RAILWAY STANDARD GONDOLA CAR.

The use of a buffer block is not new, but its arrangement in this case is somewhat novel. The iron blocks, or buffers, are rounded only on the outer half, the inner section being flat, and are backed up by an 8 x 10 in. oak block, which bears directly against the end sill. Experiments in a testing machine indicated that an oak block 8 in. thick could be compressed for 1 in. and would recover, giving a diagram which was practically ideal for a friction draft gear. Thus after the buffer comes into contact it is estimated that the cushioning effect of this block for a distance of 1 in. on each car will simply increase the draft gear capacity for that distance. (This subject was discussed by Mr. R. P. C. Sanderson at the May meeting of the New York Railroad Club.)



SIDE BEARING DETAIL.

The construction of the center plate and side bearings is shown in the illustration. Particular attention is drawn to the provision for lubrication in both of these places. The side bearing on the truck is of cast iron with a chilled face and is held in place by a cottered bolt. Cast iron liners of varying thickness are fitted in the bottom of the pocket and permit adjustment for the proper clearance.

The truck is of the regular arch bar type of somewhat heavier construction than usual. It has cast steel bolsters with the center plate riveted on. Special arrangements are required in this truck because of the fact that the cars will be hauled up an incline by means of a cable in the center of the track, which compels the location of the brake beams at a higher point than usual and necessitates the use of a special construction for preventing the tilting of the beam. This consists of a hanger secured to the inside flange of the beam and carried from a spring brass support secured to the sand plank. In other respects the truck is heavy standard practice.

This car was designed by Mr R. P. C. Sanderson, superintendent of motive power of the Virginian Railroad.

Industrial Education.—The National Society for the Promotion of Industrial Education will hold its annual meeting at Atlanta, Ga., November 19, 20 and 21. This meeting will be addressed by the most prominent educators and representatives of industrial interests in the country. An exhibition of trade school work from all parts of the U. S. will be one of the features of the convention.

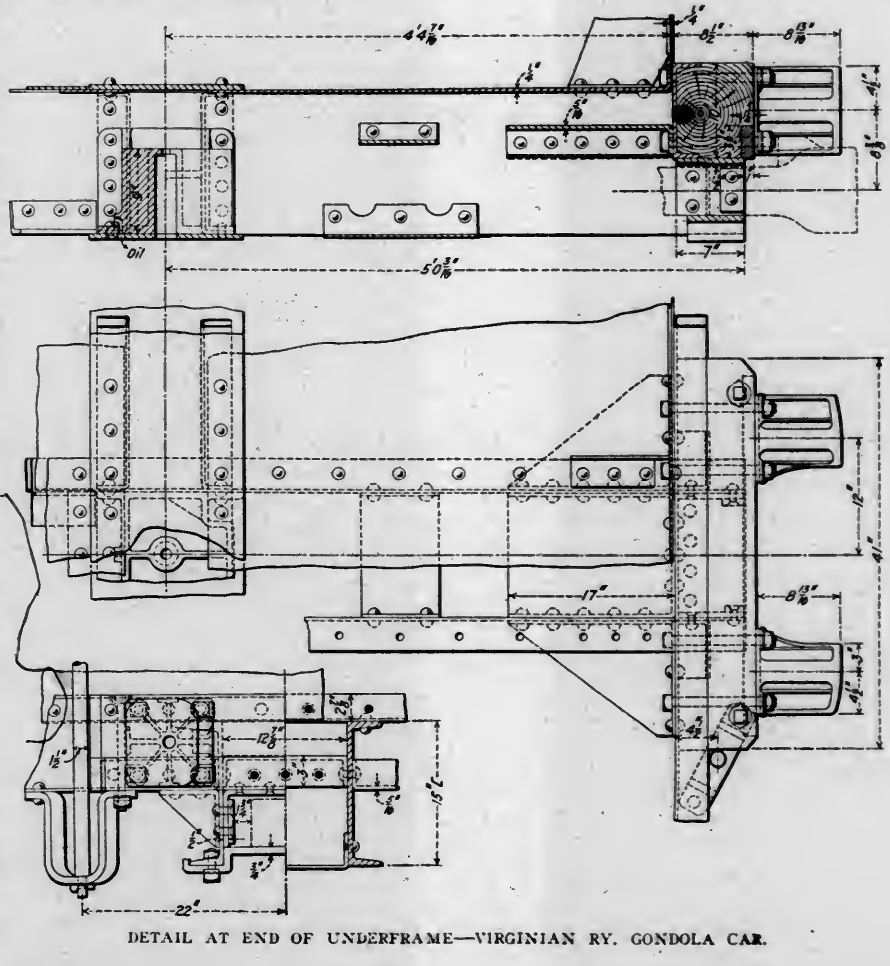
RAILWAY OFFICIALS AND EMPLOYEES ORGANIZE.

A meeting was recently held in Chicago which resulted in the formation of an organization, known as the American Railroad Employees' and Investors' Association, composed of railway officials and employees. The officials of the leading roads and of the leading brotherhoods were identified with the founding of the organization and participated in the initial meeting.

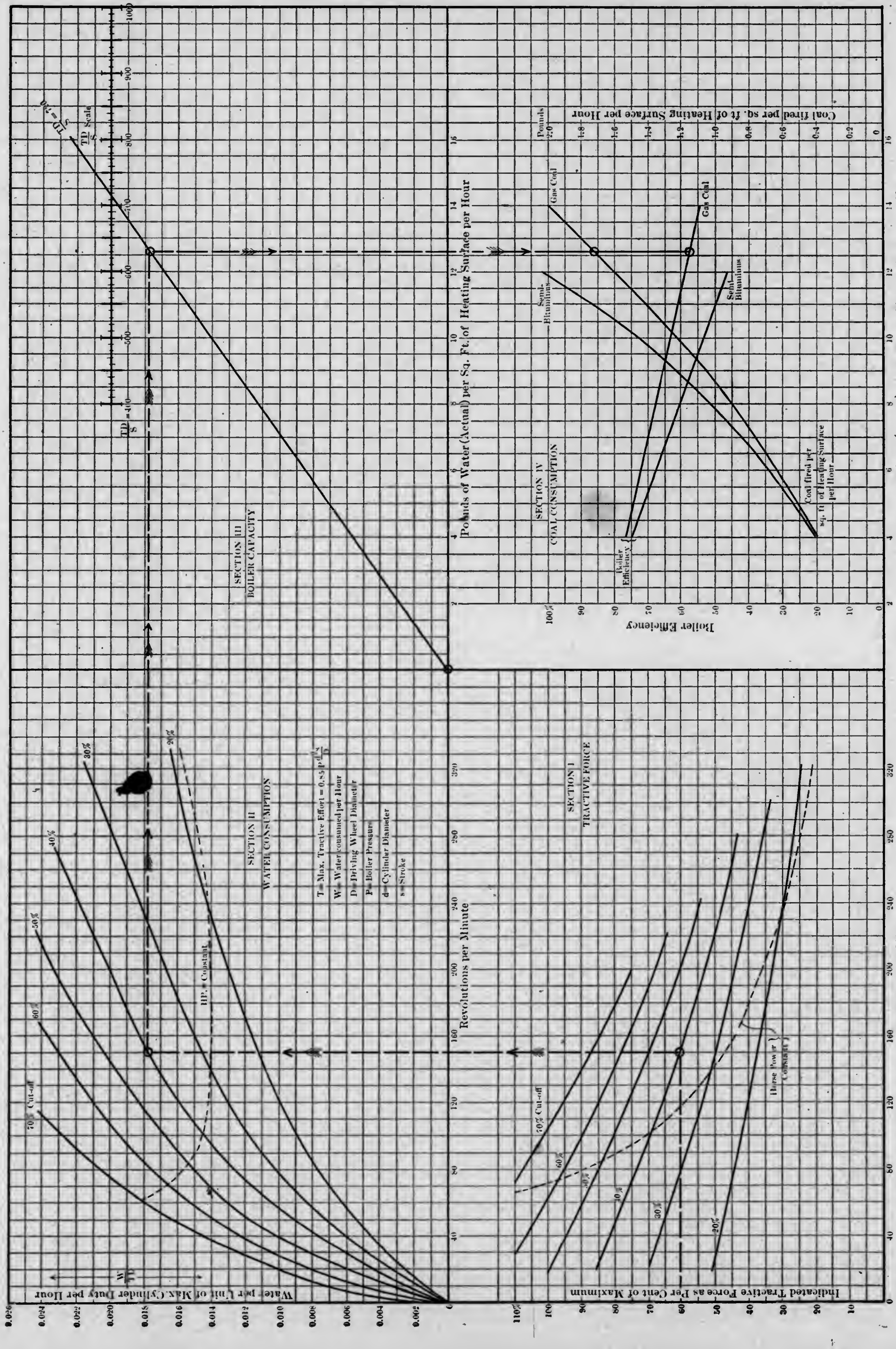
Mr. P. H. Morrissey, Grand Master of the Brotherhood of Railroad Trainmen, said that the "purpose of the American Railroad Employees' and Investors' Association shall be to use all lawful methods to cultivate and maintain between its members such a spirit of mutual interest and such concern on the part of all for the welfare and prosperity of American railroads as will best promote their successful and profitable operation for the benefit alike of their employees, investors and the public; to encourage by every proper method, cordial and friendly feelings on the part of the public toward American railroads and their business; to publicly provide means and methods for obtaining consideration and hearing from all legislative bodies and commissions empowered to enact laws, rules and regulations affecting the conduct and operation of railroads; to do whatever lawful things may be necessary in order to secure a fair return alike to capital and to labor interested in American railroads with due regard at all times to efficient service, fair treatment and safety to the public. This association shall at no time be used for partisan political purposes, nor shall it take any part in any controversy which may arise between railroad employees and road officials.

Mr. P. H. Morrissey was elected president and will appoint the secretary. Mr. Morrissey will resign his office in the B. of R. T. and devote his whole time to the new organization. The following were elected as an executive committee: A. J. Earling, E. P. Ripley, George B. Harris, B. L. Winchell, P. H. Morrissey, Warren S. Stone, E. B. Garretson and John J. Hanrahan.

The office of the association will be at 233 Railway Exchange, Chicago.



DETAIL AT END OF UNDERFRAME—VIRGINIAN RY. GONDOLA CAR.


SECTION I
TRACTIVE FORCE
SECTION II
WATER CONSUMPTION
SECTION III
BOILER CAPACITY
SECTION IV
COAL CONSUMPTION
T=Max. Tractive Effort
W=Water consumed per Hour
D=Driving Wheel Diameter
P=Boiler Pressure
d=Cylinder Diameter
s=Stroke
TD Scale
Revolutions per Minute
Pounds of Water (Actual) per Sq. Ft. of Heating Surface per Hour
Coal fired per sq. ft of Heating Surface per Hour
Boiler Efficiency
Indicated Tractive Force as Per Cent of Maximum
Water per Unit of Max. Cylinder Duty per Hour
Gas Coal
Semi-Bituminous
H.P. Constant
Horse Power Constant
Coal fired per sq. ft of Heating Surface per Hour
70% Cut-off

LOCOMOTIVE CHARACTERISTICS.

By Lawford H. Fry.

In the American Engineer of October, 1907, the writer described a method of plotting characteristic curves for a locomotive so as to present a single diagram to show the relations existing between the speed, the tractive force, the water consumption and the boiler efficiency; in fact, to chart the whole economy of the locomotive. The chart published last year was applicable only to a compound locomotive; in the present article the method is extended and a chart is given for the operation of single expansion locomotives.

As will be seen, the diagram is divided into four sections, applying respectively to (I) Tractive Force, (II) Water Consumption, (III) Boiler Capacity, and (IV) Coal Consumption.

Section I comprises a series of curves which show the relation between the indicated tractive force, the point of cut-off and the speed. The curves have been drawn for various degrees of expansions with the speeds for the ordinates, and for the abscissæ, the values of the indicated tractive force expressed as percentages of the maximum effective tractive force. This maximum tractive force, by which the indicated tractive forces are measured, is that given by the usual formula $T = 0.85\ P\frac{d^2s}{D}$, where P is the boiler pressure in pounds per square inch, d and s are respectively the cylinder diameter and stroke, and D is the driving wheel diameter in inches. By thus expressing the indicated tractive force as a percentage, and not on an absolute scale, the curves can be used to give results applicable to any normal locomotive, irrespective of its size, the actual tractive force in each case being found by multiplying the percentage by the value of T for the particular locomotive in question. The maximum effective tractive force, as given by the formula above, has been chosen as a convenient basis of measurement, but it is to be noted that it is not the maximum indicated tractive force, but is the effective force calculated by allowing 8 per cent. for machine friction and an assumed maximum mean effective pressure of 92 per cent. of the boiler pressure; as a consequence the indicated tractive force at the longer cut-offs and slow speeds is more than 100 per cent. of T.

For an example of the practical working of the chart, consider a locomotive with cylinders 20 x 26 in., with 74 in. driving wheels and a boiler pressure of 200 pounds. T = 24,000 pounds, and the curves in Section I show that if running at 150 revolutions per minute, with a cut-off of 40 per cent., the indicated tractive force will be 60 per cent. of T; that is, 14,400 pounds.

Section II contains a series of curves which give the steam consumption for any combination of speed and cut-off. These curves, like those in Section I, are adapted for general application irrespective of the dimensions of the engine under consideration, and for this reason the reading on the ordinate scale does not give the hourly water consumption direct, but gives a factor proportional to the water consumed per hour, and from which the actual weight of water is found by multiplying by T D where T is the maximum effective tractive force as above and D is the driving wheel diameter.

The curves in sections I and II are placed in such a relation to each other, that having found the tractive force corresponding to the given conditions from Section I, it is only necessary to draw a vertical through the point thus found up to the water curve in Section II for the cut-off at which the locomotive is to work. For instance, if we continue with the example commenced above, by drawing a vertical up the line of 150 revolutions, to meet the curve for 40 per cent. cut-off in Section II, the water factor is found to be 0.0176. This multiplied by T = 24,000 and by D = 74, gives an hourly steam consumption of W = 31,250 pounds.

In Section III the diagonal line serves to multiply the water factor $\frac{W}{T\ D}$ by the factor $\frac{T\ D}{S}$ where S is the heating surface in square feet, giving as a product $\frac{W}{S}$, that is, the water consumed per square foot of heating surface per hour. The factor $\frac{T\ D}{S}$, or as it is sometimes written, B D, is the maximum tractive effort multiplied by the driving wheel diameter and divided by the heating surface, and is a factor commonly used in the comparison of locomotives. In Section III a scale is provided so that for a locomotive having for $\frac{T\ D}{S}$ any value between 400 and 1,000, the proper diagonal can be drawn. The line shown in the figure is applicable to a locomotive having the cylinder dimensions examined in Sections I and II and a heating surface of 2,470 square feet, so that $\frac{T\ D}{S} = \frac{24{,}000 \times 74}{2{,}470} = 720$. The diagonal is accordingly drawn from the origin through the point 720 on the scale. It was found above that under the conditions assumed the steam consumption factor was 0.0176, and by drawing a horizontal at this height to meet the diagonal and from their point of intersection dropping a perpendicular, the water consumption is found, from the scale between Sections III and IV, to be 12.6 pounds per square foot of heating surface. It is to be noted that this figure is arrived at by taking the actual water consumption of the cylinders, not the equivalent evaporation from and at 212 degrees, and the heating surface is measured on the water side of the tubes in accordance with the usual American practice.

Now, if we have sufficient information regarding the type of boiler and the class of fuel used, we can set up a relation between the rate of evaporation per square foot of heating surface, and the boiler efficiency, and the rate of coal consumption. Two sets of curves for this purpose are plotted in Section IV. These curves are derived from tests of the boilers of the Pennsylvania Railroad Atlantic type engines, and of the two sets of curves that for the semi-bituminous coal is from the tests described by the committee of the Master Mechanics' Association in their report on Balanced Compound Locomotives, while the set of curves for the bituminous gas coal is from the tests described in the paper by the writer read before the Institution of Mechanical Engineers, in April of this year.* It will be noticed that the gas coal gives the higher efficiency and a greater capacity—14 as against 12 pounds of water per square foot of heating surface. From these curves it is a simple matter to read off the boiler efficiency and the rate of firing per square foot of heating surface, while the weight of coal per square foot of heating surface per hour multiplied by the heating surface gives the total coal consumption per hour. Continuing the example already begun, we find from the curves in Section IV a boiler efficiency of 57 per cent. and a coal consumption of 1.72 pounds per square foot of heating surface, which gives a total of 1.72 x 2,470 = 4,250 pounds per hour with gas coal as fuel.

From the foregoing it is obvious that the coal and water consumption for a given locomotive under given service conditions are very readily found from the curves. In the chart the scales for the curves are marked in percentages and factors, so that they are of general application, but for any given locomotive a chart can be drawn with the speeds in miles per hour, the tractive forces in pounds, and the total water and coal consumption in pounds per hour. In either form the curves should be of considerable service in determining the dimensions to be required by a locomotive for a given service, or in studying the question of tonnage rating for an existing engine.

To those interested in carrying out calculations regarding the economy of the locomotive it will be clear that the curves given carry considerably more information than that which they are designed to give by a direct reading. For example, if we desig-

* See American Engineer, May, 1908, page 186.

nate the indicated tractive force at any speed by T, the indicated horse power is $\frac{T_1 \times V}{375}$ where V is the speed in miles per hour, and since $V = \frac{nD}{336}$ where n is the number of revolutions per minute and D the driving wheel diameter in inches, if we designate the indicated horse power by H_1 we have

$$H_1 = \frac{T_1 n D}{126{,}000} \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Further, if we express the relation between the indicated tractive force at the given speed, T_1, and the maximum tractive force T by writing $T_1 = p\,T$, p will be the percentage given by the curves in Section I for the given speed and cut-off, and we can transform equation (1) to the form,

$$H_1 = p\,n \frac{T D}{126{,}000} \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Which is to say that the indicated horsepower is given by multiplying the percentage "p" from Section I by the speed in revolutions, and by a constant factor dependent on the cylinder dimensions.

Equation (2) enables us to determine how the point of cut-off must be varied with a change in the speed so as to maintain the horsepower constant. If the horsepower is to be constant the product "p n" must remain constant. It is of course easy to draw in Section I any number of curves, such as that shown by the broken line, on which the relation "p n = const." is maintained. On the dotted curve p n = 71, and this, with the locomotive considered above with cylinders 20 x 26 and 200 pounds boiler pressure, corresponds to an indicated horsepower of 1000. Now, if from the points of intersection of the constant horsepower curve with the various cut-off curves in Section I we draw verticals to meet the corresponding cut-off curves in Section II, we connect these points as shown by the dotted line and obtain in Section II a curve showing how the hourly steam consumption varies with the speed when the horsepower remains constant. The curve drawn shows that for this particular horsepower the steam consumption is least for speeds between 160 and 200 revolutions per minute.

The chart further enables a determination to be made of the water consumed per horsepower per hour. This determination can be carried out for any combination of speed and cut-off without reference to the size of the engine. From the expression for its indicated horsepower in equation (2) we find that, if W is the total hourly steam consumption, the steam consumed per indicated horsepower hour is:

$$\frac{W}{H_1} = \frac{W}{T D} \times \frac{1}{p} \times \frac{126{,}000}{n} \ldots\ldots\ldots\ldots (3)$$

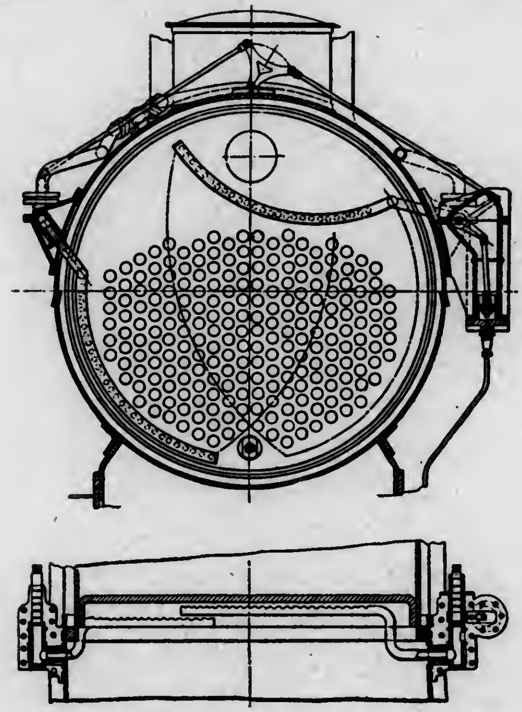
That is to say, for any given conditions of operation the water per indicated horsepower hour is found by dividing the value of $\frac{W}{TD}$ from Section II by the value of p from Section I, and by n, the number of revolutions per minute and multiplying the result by 126,000. For example, at 150 revolutions per minute and a cut-off of 30 per cent., we find from the curves in Section II, $\frac{W}{TD} = 0.0145$, and in Section I, p = 0.475. Consequently the steam per horsepower hour is $\frac{W}{H_1} = \frac{0.0145}{0.475} \times \frac{126{,}000}{150} = 25.7$ lbs.

A comparison of this and other similar results from the chart with the results of other experiments seems to indicate that the chart is closely representative of the operation of a normal single expansion locomotive.

TUBE BLOWING DEVICE.

Messrs. Henschel & Son, locomotive builders, of Cassel, Germany, have equipped a number of locomotives on the Prussian State Railways with a tube blowing device, which is said to have met with considerable success. This arrangement is shown in the accompanying illustration, which is taken from *Engineering* (London) and consists of two swinging arms formed of pipes with perforations along one side through which steam is blown. These pipes move up and down in front of the smoke box tube sheet and the jets of steam are blown through the tubes, cleaning them out.

The motion of the arms is obtained either by hand or by power, the example shown being of the latter type. It is operated



TUBE BLOWING DEVICE—PRUSSIAN STATE RAILWAYS.

by means of a small steam cylinder with a trunk piston, secured on one side of the front end, which controls the movement of both pipes by means of a connection over the top of the boiler. There is an operating valve in the cab which has three positions, the center being shut off position and a movement either side of this admits steam to the blower pipes and to the operating cylinder, one way forcing the piston up and making one sweep of the pipes with the blowers and the other way forcing it down and bringing them back again.

It will be noted that the arrangement is such that when one arm moves up the other moves down and that all of the tubes are blown, those in the center being covered twice in each sweep.

It is evident that by means of a device of this kind the tubes could be blown while the engine was taking water or standing on the side track and oftentimes would prevent them from becoming clogged up solid.

THE RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION CONVENTION.—The tenth annual convention of the American Railway Engineering and Maintenance of Way Association will be held at the Auditorium Hotel, Chicago, March 16 to 18, 1909. It is expected that in honor of the completion of the first decade of its existence, the convention will be unusually large and important. The program is very full and it will be difficult to get through it in the usual three days. The question of holding the convention at the Coliseum in connection with the track exhibit was decided in the negative last March and will not be again reopened this year.

A RATIONAL SYSTEM OF NUMBERING.

BY C. J. MORRISON.*

From the earliest ages it has been customary when one of any article was secured to assign to it the digit, or symbol, representing the first unit of the numbering system, and if another was obtained, to assign the second number, and so on. Thus, if a merchant has one wagon it is No. 1, and if he enlarges his business and gets another wagon, it is No. 2. Such a system may be all right for this purpose, but falls far short of answering the real needs when applied to numbering machines in a shop, or locomotives on the road. Yet such a system is used largely in numbering the locomotives, and almost universally in numbering machines. It is easily possible in a shop of ordinary size, by using four figures in the number of each machine, to make the numbers show the class of machine and its location. In a shop of unusually large size it may be necessary to use five figures in the numbers for machines in certain positions of the shop.

The system that has been used in one large shop for the past three years is as follows: The first two figures of the number show the class of machine, *i.e.*, lathe, planer, shaper, saw, etc., while the last two or three figures show the shop in which the machine is located. As the numbers advance from the south in shops running north and south, and from the west in shops running east and west, the number also gives a close approximation to the position in the shop. For example, 0465 is a lathe in the east machine shop, while 0415 is a lathe in the tool room. When five figures are used the machines in a shop of almost unlimited proportions can be numbered. The complete system for a very large shop is as shown below. Four figures are used in the machine shop proper, while five figures are used in all the other shops.

CLASSES OF MACHINES.

No. of Class.	Machine.
00	Bolt Cutters
01	Planers
02	Shapers
03	Milling Machines
04	Lathes
05	Vertical Boring and Turning Mills
06	Drill Presses
07	Abrasive Wheels
08	Miscellaneous Machines, (such as Cock Grinders, Triple Valve Grinders, etc.)
09	Quartering Machines
10	Wheel Presses
11	Gear Cutters
12	Horizontal Boring Mills
13	Wheel Lathes
14	Slotters
15	Nut Facers
16	Centering Machines
17	Special Tin Shop Machines
18	Special Belting Machines
19	Pipe Machines
20	Presses
21	Oil Separators
22	Nut Tappers
23	Motors, Electric
24	Motors, Air
25	Bolt Turning Machines
26 to 30	Vacant for New Machines
31	Rattlers
32	Punches and Shears
33	Rolls
34	Flue Cutters
35	Flue Welders
36	Saws
37	Riveters
38	Stay Bolt Finishers
39	Blowers
40	Clamps
41	Forges
42	Furnaces
43	Steam Hammers
44	Stationary Air Hammers for Welding
45	Bolt Headers
46	Bull Dozers
47	Forging Machines
48	Spring Making Machinery
49	Gainers
50	Universal Wood Workers
51	Mortisers
52	Matchers
53	Tenoners
54	Buffers
55	Plating Machinery
56	Hair Pickers
57	Jammers
58	Air Hose Coupling Machines
59	Air Hose Splicing and Extracting Machines
60	Transfer Tables
61	Cranes

* Standardizing Engineer, A. T. & S. F. Ry. System.

ASSIGNMENT OF NUMBERS FOR DIFFERENT SHOPS.

No.	Shop.
	MACHINE SHOP PROPER.
00 to 19	Tool Room
20 to 49	Brass Room
50 to 59	Air Room
60 to 64	West Machine Shop
65 to 99	East Machine Shop
	OTHER SHOPS.
100 to 150	Boiler Shop
151 to 199	Water Service
200 to 250	West Wheel Shop
251 to 299	Pattern Shop
300 to 350	Cabinet Shop
351 to 399	West Car Shop
400 to 499	Blacksmith Shop
500 to 550	West Planing Mill
551 to 599	East Wheel Shop
600 to 650	East Planing Mill
651 to 699	East Car Shop
700 to 750	Steel Car Shop
751 to 999	Vacant for Extensions
Example:—	
0115	Planer in Tool Room
0163	Planer in West Machine Shop
0175	Planer in East Machine Shop
01156	Planer in Water Service
01501	Planer in West Planing Mill
01675	Planer in East Planing Mill

The same system may be applied to numbering locomotives with equally good results. On a large system, composed of a combination of small roads, by using four figures in each number, the road upon which the locomotive is running and the class of engine can be shown. Thus, the first figure could be used to designate the road and the last three figures the class of locomotive. Example:

All locomotives with the first figure 0 mean A. B. C. Ry.;
" " " " " " 1 " H. R. T. Ry.;
" " " " " " 2 " X. N. Y. Ry.;
" " " " " " 3 " W. K. S. Ry.;
All locomotives with the second figure 1 are eight wheelers.
" " " " " " 2 are moguls.
" " " " second figure 3 are ten wheelers.
" " " " last two figures 01 to 50 are simple.
" " " " " " " 51 to 99 are compound.
And so on.

Thus, locomotive 0101 is an eight wheeler on the A. B. C. Ry., while 1101 is an eight wheeler on the H. R. T. Ry.; 0310 is a ten wheel simple locomotive on the A. B. C. Ry., while 0355 is a ten wheel compound on the same road. Although the system may at first seem a little complicated, it is really very simple and easy to learn. By the use of a fifth figure considerable additional information, such as size of wheels, weight, etc., may be shown. However, it hardly seems advisable to use a fifth figure in the case of locomotives. On systems where it is not necessary to show the roads on which the locomotive is running, the figures may be used to show weight, tractive effort, or similar information.

With reference to the machines, this system has proved very valuable when extended to all of the shops on a large railroad system. Everyone soon became familiar with the symbols, so that when a master mechanic referred to machine 0463, everyone knew he referred to a lathe. Telegraphic reports, requests for repair parts, etc., needed to only quote the number to give all required information.

One of the most useful applications of the system was the numbering of schedules for work. By numbering the schedules on the same system as the machines, the machine upon which the work was to be done was immediately shown.

The system does not need to end with the numbering of machines, schedules and locomotives, but may be extended to the employees, shop orders, general instructions, and, in fact, to any collection of objects, information or persons requiring numbers.

COMBINED RECIPROCATING AND TURBINE ENGINES IN STEAMSHIP.—The Dominion liner "Laurentic," which was recently launched at Belfast, is of special interest on account of the adoption in this vessel of a combination of reciprocating engines with a low pressure turbine. The vessel is tripled screwed, each of the wing propellers being driven by a four-cylinder triple expansion engine and the center propeller by a turbine. In this way the economic advantage of complete expansion of the steam is obtained and the necessity for separate turbines for astern movement is eliminated. The "Laurentic" is 565 feet long, 67 ft. 4 in. beam and has a gross tonnage of 14,500. She will be used in the Canada trade.

STEEL PASSENGER EQUIPMENT.*

ARRANGEMENT OF UNDERFRAME.—FORM III.

BY CHAS. E. BARBA AND MARVIN SINGER.

Of the three general methods of load carrying by the underframe, the first two have been discussed in previous chapters.† They comprise:

Form I, which carries the load upon the side girder and opposes a nominal center sill section to end shocks.

Form II carries the whole load upon the center sills, which are of a large sectional area to oppose end shocks.

Form III, the basis of this article, is really a combination of both the other forms—carrying load upon side, center and intermediate sills, if any, and endeavoring to oppose all of them to end shock. The report of the last M. C. B. Association committee upon this topic recognizes the same underframe forms we have analyzed, and, speaking of the third form, says: "Third: That in which the center and side rails with truss rods and the general construction of wooden cars is reproduced in metal. The Southern Pacific car may be given as an example of this class."

The previous articles contain references to this form of underframe—upon page 461, December, 1907, as follows: "The third form is characteristic of a majority of all the equipment now in use. Herein all sills carry loads to a bolster." The previous page of the same issue shows this form diagrammatically.

PROMINENT EXAMPLES OF THIS FORM IN STEEL.

Of cars illustrating this type with underframes widely differing from one another in detail construction, may be mentioned:

(1) The composite car for the Illinois Central R. R. (1903) which used 9" 21 lb. I-beams for center and side sills. The whole floor was covered with a 1/4" plate and four 1 1/4" truss rods were used.

(2) The first car built for the Interborough Rapid Transit Co. in 1904 used a composite underframe of wood and steel with 1 1/4" truss rods. The center sills were composed of 2-5" 12.25 lb. I-beams, each sandwiched between 5" x 8" wooden stringers. The side sills were of 6" 8 lb. channels with a 3 1/4" x 6" stringer outside and a 3 1/4" x 7" stringer inside. The future of this car is of note in that the center sills were later changed to built up I-sections from 5" Z and 2-4" x 4" angles, while the side sill was reduced to a 5" x 3" angle. The latest type now uses 6" 17.25 lb. I for the center sills. Flitched or sandwiched beams have thus been relegated.

(3) The car designed by Mr. G. I. King for the M. C. B. convention of 1904. This car uses two 1 3/4" truss rods, a box girder center sill with a 24" x 1/2" top cover plate, 12" 25 lb. channels, with their bottom flange reinforced by a 1" x 6" plate. The bottom being double latticed. The side girder consisting of 1/4" steel plate, 41 3/8" deep, reinforced at the top by 2 1/2" x 2 1/2" x 1/2" angle and the bottom by a 3" x 3" x 1/2" angle.

(4) The Pressed Steel Car Co. exhibited a car built for the Southern Ry. at the 1906 M. C. B. convention, in which the center sills were built up, channel section, with a 21 1/2" x 1/4" top cover plate. The web of channel being of 3/8" plate 22" deep at the center and 13 1/8" over the truck centers, reinforced top and bottom with 3 1/2" x 3 1/2" x 1/2" angles. The side girder was composed of 0.3" plates 36" deep, with a 5" x 3" x 1/2" side sill angle.

(5) The Santa Fe (1905) steel underframe shows no side girder, both center and side sills being fishbellied of built up construction. The center sill was similar to the construction of the Southern, but of the following dimensions:

Top cover plate..24" x 1/4"
Web..24" x 5/16"
Angles..........................3" x 3" x 1/4" (1 per web top)
Angles......................3" x 3" x 1/4" (2 per web bottom)

The side girder was of 5/16" plate 23" deep, two 3" x 3" x 5/8" bottom angles and 4" x 3" x 5/16" top angle and a 3" Z supporting a nailing sill of wood 3 3/8" x 5".

(6) The Southern and Union Pacific Lines use two 1 1/2" truss rods with 12" 31.5 lb. I for the center sills and a 3 1/2" x 7" x 1/2" side sill angle at the bottom of the deep side girder.

(7) The C. I. & L. combined car shows two 1 1/2" truss rods with sandwiched 8" 18 lb. I-beams, with a 7" x 8" wooden beam for center sills and 6 1/2" for side sills.

These cars vary so much in area for the various members and in load carrying imposed upon them that general remarks cannot be made to fit each case. However, the maximum center sill area provided for in any of them is 31 sq. in. (not including the proposed car of Mr. King), which will give a direct stress of 12,900 lbs. per sq. in. for end shock alone. This stress, however, does not include the effect of eccentric action of end load nor the strain of lading, which would undoubtedly cause all of these cars to lie outside of the recommendations of the Master Car Builders' Association.

In reference to the cars with flitched stringers or sandwiched beams, it may be noted that one of the largest systems has in its experience pronounced them a failure and at one time had its yards piled full of beams which were not used as intended because the sample car showed itself to be a flat failure. The difference between the moduli of elasticity of wood and steel is so marked that it is impossible to secure the advantages of the flexibility of the wood and the rigidity of the steel without a better union between the two than bolting together will afford. For strength but the steel can be depended upon—the weight of wood is hence almost useless except as nailing sills.

The whole idea in the use of this double construction, aside from the nailing facilities, was to secure better riding properties than an all-steel construction would give. It is now known that the all-steel car rides as well if not better than the wooden ones. The combination of two materials into a common beam or column for car underframes is not economically defensible.

EVOLUTION OF FORM III.

The fact that this type of underframe is now so universal in wooden equipment makes its evolution of interest. The interest centers particularly about the recognized fact that when it is desired to change a means of force resistance by utilizing a different material it is proper to know how the present form of resistance came to be introduced and see if we would not fundamentally alter the form of resistance from the very beginning.

Then there should also be considered the fact that what is now in existence may not represent what is best from the engineering standpoint. The designer in the days gone by was handicapped by market conditions. He must take what is provided and not expect steel companies to produce according to his idea. Indeed, even now the same holds true, except for a large consumer. Thus the old fallacies are perpetuated.

The larger corporations can secure the sections they desire. This brings up the point of the larger roads taking the initiative and having the smaller roads influenced in details by such action through the M. C. B. Association. The report of the recent committee appointed by that body to consider the question of "Steel Passenger Cars" unfortunately brought but little before the association, but what had been accumulating in the technical magazines since 1903. Historically and as a compilation of such data it is good; otherwise it is too equivocal.

† See Résumé at the end of this article.

It is noteworthy that they recommended a standard method of end shock measurement—400,000 lbs. at a combined stress of from 12,500 to 15,000 lbs. per sq. in., and for suburban service 20,000 lbs. per sq. in. This figure is much higher than we advocated and is one in which it will be a difficult matter to find a car to stand among the equipment listed in the report.

This recommendation is a great stride in the right direction and it is to be hoped that the next few years will see the three underframe types, particularly the first two, worked out for the service to which they belong and adopted as standard. It would be of as much advantage to produce a method of calculation similarly to that evolved for axles, so as to provide for uniformity in unusual or special cases.

Before 1850 it was unusual to find a car with a platform for side ingress or egress. The customary construction was simply a bumper beam such as is now found in good freight equipment. Where hook and link couplers were used, they were attached by chains directly to the sills, while the link and pin showed a small block of wood for a platform sill. This block was attached to the short center sills. These sills extended back to the bolster, which came in with the introduction of four-wheeled trucks, being the embryo from which the later development came. The necessity for these sills was found in the attachment of the yoke draw bar for the link coupler.

The platform end sill was then originally a short bumper block. Continual bumping shoved the bolster and end sill out of transverse alignment, after which intermediate sills were placed between them. These served to stiffen up the whole end of the car to a marked degree, but even this expedient failed to answer the purpose intended, so that a single longitudinal sill was introduced between bolsters.

The load was thence put upon the bolsters by the two center sills and taken by the single center sill and probably in a small degree by the side sills.

Accidents, however, have shown this to be unsatisfactory, so that the center sill was doubled and made to directly oppose the disjointed center sills on the far side of the bolster. The body end sill was then put out of direct collision by expanding the platform end sill and using the platform for loading.

The intermediate sills were now carried through from the bolster to the body end sill. Thus there were four platform sills with additional draft sills running to the bolster and between the bolsters, the two side and two center sills, so that the introduction of all central sills and platform sills was as an end shock measure and not for load carrying in a vertical plane.

This idea is the basis from which all forms are now worked out, the only difference being in determining what proportion of the vertical load comes upon the center sills.

The destructive action of end shocks next introduced the intermediate sills not as we now have them, but as long diagonals from the body corner post to the center sills at the center of the car.

There is in existence—though not now running—a steel underframe car designed about 20 years ago with these diagonal struts, and no trucks, the journal boxes working in pedestals fastened directly to the underframe.

These diagonal sills were afterwards made to parallel the center and side sills and shorter diagonal struts introduced, dividing the floor of the car into 3 or 4 trussed panel lengths. A type of such an underframe was illustrated in Fig. 2, page 454, December, 1907, issue.

A particularly noteworthy feature of this underframe, which is that of the class "Pa." car of the P. R. R. (1858), is that the car framing between body end sills is a unit and the platform entirely separate. The end load is given to the underframe by separate platform sills.

A half century later the change in the underframe for cars has not been marked to any especial degree. A comparison of this coach run in the days where end shocks and service demands were very small compared with the present, reveals the fallacy of the defense of most of the present underframe systems as reliable and satisfactory.

This car (class Pa.) possessed 230 sq. in. for a short car of about 46 ft. over end sheets. The same road now uses 304 sq. in. in their standard coaches of almost half again the original length. Thus the short car of 50 years ago possessed about 3/4 the sill area now provided for the longer cars.

The first class passenger coaches of several prominent Eastern roads provide about 190 sq. in. of sill area. Hence these cars now possess but 4/5 the underframe area given to the P. R. R. coach years ago.

The box cars now possess a wooden underframe of about 280 sq. in. These present a poor showing when in a wreck with the steel freight cars; much more so would the passenger cars with weaker underframes fare under similar conditions.

This form (III) in steel has come into use very gradually. As an instance, the platform became so heavy with its reinforcements that the car framing could not preserve the proper alignment; in repairing old cars for these defects, as well as decayed and broken sills, the wooden stringers were replaced by steel channels or eye beams. This gradually grew into a full steel underframe. Interchangeability argued for the same form in the all-steel equipment and thus the design has been perpetuated notwithstanding it was originally a makeshift. Again the subject has come up, in some cases so suddenly as to permit of little extended investigation as to the possibilities of using steel, so that the older framing was replaced, with but few evident touches, in steel.

The shortness of time available between starting the design and the placing of the order has seriously hampered some designers. The resulting trouble in the shop due to oversight in design has given the subject a black eye on some roads.

It is unfortunate that the managements do not usually foresee the difficulties involved in such a problem, granting at least a year to the designers to evolve a design which will not only be satisfactory for the initial order, but from which future orders of cars of different lengths and character can be constructed most expeditiously.

The research work necessary to determine the possibilities of an all-steel equipment over that of wood is enormous, not only from a manufacturing standpoint, but also in the method of load transference.

There is no doubt in our minds that the labor thus spent is well repaid by the decreased cost of maintenance and interchangeability, so that after the first development any type of car can be designed at short notice with a larger degree of accuracy than has ever before been attempted.

The adoption of the same underframe for the steel as the replaced steel underframe in wooden cars was essentially an economic move, because changes in steel involve considerably more expense than in wood, throughout the design and construction. Accurate information is required; about three times as many drawings go to complete a steel car design as the wooden. All details must be drawn out and dimensioned. The shop must make new dies, templates and jigs, notwithstanding the difficulty involved in reorganizing the shop forces.

There is no reason which can be advanced to justify the use of the form III type of underframe for high speed passenger service over and above that of Forms I and II. Indeed, its use is not only not justified and the advantages claimed for it are more fictitious than real.

For this form to be constructed to secure lightness and economy it must sacrifice strength, which Forms I and II will provide for the same weight. This is especially true for those designs of this form which use intermediate stringers. The intermediate stringer other than the center and side sills are unnecessary and an extravagance. The form is very strong up to the body end sill and bolster, but much weaker in the body of the car, which, of course, is fatal to its use in trains with the other forms. The sills being shallow beams distributed over the floor take uneven loads from the superstructure lading and from any assumed end shock.

These unequal strains cannot even be approximated within

any respectable degree of the correctness of the approximations which can be made for Forms I and II.

All the work of designing a car framing is more or less approximate, in so far as the assumptions for external forces and their shock or strain transference is concerned. This, however, does not mean that it must be very loosely so, although it is in some cases where the framing is disposed so that a mathematical analysis provides nothing of security to rest upon.

The method pursued in one office when designing a steel car to replace a wooden one is to take the area in wood, divide the area and modulus of resistance by 4 and replace by this value in steel. This is so loose it almost falls apart; it might answer in a way were the wooden cars sufficiently reliable, but the balance is the other way since the assumptions upon which the data is obtained are admittedly false.

In the past the proper proportions of the framing members has not been one of calculation whatever; the same sections were used for cars 50, 60, 70 and 80 ft. long, reliance being placed in the truss rods to carry the extra load.

Whatever calculations were made were not as reliable from an engineering standpoint as popular acceptance would seem to indicate. The framing arrangement with the intermediate sills is quite impossible of just analysis, as load transference can be known to take place in so many different ways.

The argument that the end shock used as a basis of design is but an assumption and may vary from 0 to a maximum, is no just cause for laxity in the method used to provide for this basis. This method should be as exact as engineering knowledge will permit else for loose data the possibility is just as great that the error in result will be to combine errors of data and formulæ as it is to neutralize them and make the result almost accurate.

The whole essential thought is centered about the material. An engineer's work involves but few questions when a subject such as the one under discussion is involved—what material, how disposed and what form shall it be used in to meet the requirements?

This was the idea involved in our previous references as to how the engineer can identify himself with his material. The process of underframe design is but to use the best material, so disposed that the strains must be taken as designed and resisted by the most economical sections.

It is possible to design an underframe of any form for any service, but to do so the question of weight and economy must not be neglected. This is the fault with those forms which seek to make the division of the end shock and lading distributed over all sills.

The main point then to be learned from a study of the equipment and the changes involved is that the intermediate sills are not of importance when the underframe is of steel; that truss rods should be omitted and that this weight should be used for side or center sill strengthening.

The great variety in the underframe members noted in the list at the beginning of the article is due in a great measure to the character of the superstructure.

A wooden structure upon steel underframe must have sufficient rigidity to avoid the use of truss rods, which means the side must either extend up from the side sills as a plate girder or be fishbellied below the side sills. When the side plate is used the car is of composite construction. The second makes it but a steel underframe.

This change, using either a side girder or fishbellied side sills, will adapt any of the previous underframe forms to composite or an all-wood superstructure, with the addition of suitable nailing sills. The essential points to remember being that the side girder or truss must be inherently capable of vertical load carrying between supports.

The use of a large steel casting as the underframe for the platform back to and including the bolster does not seem advisable for various reasons. If made of uniform strength, there is a great probability of it breaking in collisions somewhere between the body end sill and bolster and thereby making the repairing not only a difficult task, but also subjected to much waste. Again, it may be so much stronger than the body underframe that a collision would wreck the center of the car before damaging the castings.

The ideal steel casting should at least be double and detachable. One portion acting as the bolster and the end sill, while the other or several others were bolted to it for the platform.

This brings up the question of the congestion of apparatus underneath the platform and means of their support. These are steam heat and air brake pipes, draft gear and buffing arrangement, electrical connectors, coupler release rigging and hand brakes. A suitable casting might be made to simplify the attachment of these accessories.

Drooping Car Ends.

The steel casting which is used for the end sill and bolster or the cast steel bolster itself should have the spacing of the bolster legs a goodly distance apart, as this is a measure destined to avoid the trouble experienced with drooping platform ends.

In reviewing designs of double bolsters of cars covering a period of 25 years the spread of the legs has been found to be about 5' 0" and that the distance from the center plate to the body end sill is about 6' 10". The support is thus about halfway between end sill and what it would be for a single leg bolster. The single leg bolster should not be used where trouble in alignment of platforms is anticipated.

To obviate the difficulties thus encountered, various expedients have been tried, none of which seem to have relieved the droop. Amongst the most notable of the various forms of reinforcement, for body end sill and platforms, are the use of intermediate platform sills of either I-beam or channel section and running back to the body bolster and even beyond. This form secures strength by excessive weights and is one of the forms known to give trouble by drooping.

The use of steel plates on the inside of letter boards to support the vestibule corner post is another example of present practice, but even this is bad on account of the encroachment of the side entrance doors, when designed for high platforms, in reducing the section area of the plate.

Another form, and one which is prevalent on our heavier equipment, is the use of an inverted truss placed over the bolster, one end of which is tied to the side sill beyond the bolster towards the center of the car, while the other end is used in suspending the intersection of side sill with body end sill, by means of a truss rod.

The introduction of steel equipment is hailed with delight by the shops as a means of relief from these alignment troubles, as with wood they were up to the limit and beyond it, as the increased cost of repairs have proven.

Provisions for Apparatus.

Load carrying conditions being equal, that type of underframe is best which provides the most satisfactory arrangements for the carrying of apparatus underneath the car. This apparatus is now quite complex; there are gas tanks or battery boxes, water tanks, air reservoirs and cylinder, brake gear, water, air, steam and lighting piping, provision boxes and multiple unit control apparatus. These may not be all on one car, but provision must be made for them on an interchangeable underframe.

The fishbellied center and side sills are not the most satisfactory for this reason; heavy apparatus should be as near the center of the car and the trucks as possible. Truss rods interfere; on some cars it has been necessary to use two turnbuckles per truss due to apparatus interference. The side girder with box girder center sills best answers the above requirement.

Strain Transference.

One feature which would prejudice this design in the eyes of a car designer is the inability of forecasting with any good measure of certainty just what course the strains incident to service will follow throughout the framing members.

The center sills always are continuous over platforms, separate draft timbers are secured to these below the platform and run back to the bolster, at about the plane of the top step riser, and intermediate sills are run back from the platform end sill

and likewise terminate at the bolster. This makes a strong platform—very strong; in fact, much stronger than the car between the bolsters. The idea evidently in the mind of the designers of this form of car was that the bolsters should distribute the load put upon them by these sills to the intermediate and side sills, as well as the center sills.

The intermediate sills may act as a fulcrum and the sides get no load whatever, or the sides act as the fulcrum and then they become reaction points and thereby impart loads to the other sills. This case can be summed up as follows:

If the bolster had no deflection in the transverse horizontal plane then the sills would take the load equally or to the limit of their capability; this condition, however, will not hold because in practice the bolsters will defect, the action of which will cause excessive loads being placed upon the center sills with less upon the intermediate and little upon the side sills. If the permissible compression of the center sills is sufficient to permit this condition to hold, then the intermediate sills get their smallest proportion.

With no intermediate sills the condition imposed upon the center sills as far as end shocks is concerned is worse. The matter is one of great doubt throughout.

Fundamentally all car frames must carry their own weights and the relatively small proportion of baggage or personal load; it is just as fundamental a fact that they must be formed to resist end shock. What this end shock may be has been covered in general on page 82, February, 1908.

Thus the provisions which are made for these destructive buffing strains must be capable of standing up to the data secured from a most careful study of the conditions under which the cars will operate, so that an analysis of the suitability of any framing design will hence depend upon the service and type of equipment in use.

This form of car should be used for but that type of service which must needs have the smallest end shock; it is not adapted to as large end shocks for economical building as Form I, much less for Form II. It is adapted to every type of car now running, but when electric service is considered, this is not the car it should be on account of the interference of the truss rods or fishbellied side sills with the apparatus underneath the car.

RESUME.

THE UNDERFRAME PROBLEM.

The data upon which this problem is formulated are in general:

"The demands of the service for which the vehicle is intended and the resistances and destructive forces which it must overcome in such service." (See page 453, Dec., '07, issue.)

The sources from which these data are secured are first the operative and passenger departments. In some cases the items of information are definite and complete, and in others must necessarily be approximated. These items include studies of

(a) Traffic and schedules.
(b) Character of trains.
(c) Number of trains.
(d) Speeds and headway.
(e) Ingress and egress facilities.
(f) Seating capacity.
(g) Length.
(h) Permissible weight.
(i) Maximum cost.
(j) Character of motive power.
(k) Allowable clearances.

Other items may be specified and most probably will be, concerning various detail arrangements which must be incorporated.

The service conditions which produce different demands are those for train and separate unit running. (See p. 455, Dec., '07.)

Under these heads would come the problems associated with the probable change of motive power unit and the strength and reliability factors covering end shocks and vertical lading. (See pp. 455 to 459. The more prominent limitations concerning lightness and economy are found on p. 454.)

ARRANGEMENT OF UNDERFRAME MEMBERS. (p. 461, '07.)

FORM I, PP. 81-83, FEB., 1908.

Load Carrying.—The weight of superstructure and lading is taken by the side girder. Buffing and pulling strains are assumed by the center sills.
Utility—Best for nominal end shocks and cars without central side entrances. Good for multiple unit control (p. 81).
Center Sills—Weak and light—nature of a uniformly loaded continuous beam (p. 83) with end load (p. 84 and p. 153).
Transverse Supports—Nature of a simple beam loaded by center sills both vertically and transversely (p. 156).
Floor Girder—Trussed—Plate—Formed of center sills and side sills in a horizontal plane and used to assist in end shocks (p. 156).
Side Girder—Formed of side sill angles—side plates and belt rail with posts as vertical stiffeners. Loaded from the transverse supports and superstructure (p. 235).

FORM II.

Load Carrying—All loads from superstructure, lading and end shocks taken by the center sills (p. 234).
Utility—The best form for severe service with heavy end shocks; can be used for every type of equipment (p. 235).
Center Sills—Box Girder or Trussed—of the nature of a uniformly loaded overhanging beam with end load (p. 236).
Transverse Cantilevers—Double cantilevers—loaded at each end and supported at the center.
Side Girder—Continuous deck beam of depth between side sills and belt rail loaded with superstructure weight and lading which is transferred to center sills through the transverse cantilevers (p. 238).

FORM III.

Load Carrying—All longitudinal sills carry weight of superstructure and lading. End shocks opposed mainly by the center sills.
Utility—Not adapted to as severe end shocks as Form II for economical building.
Center Sills—Uniformly loaded overhanging beam, subject to end shock.
Intermediate Sills—Uniformly loaded overhanging beams.
Side Sills—Uniformly loaded overhanging beams.
Transverse Supports—Endeavor to equalize load carrying of longitudinal sills.

MELTING SNOW AT FROGS AND SWITCHES.

A new method of snow melting by means of a hydrocarbon fluid was described in a paper presented by J. S. Lang, M. Am. Soc. M. E., at a recent meeting of the Railway Signal Association. The practicability of this method, according to Mr. Lang, has been demonstrated by its use for the purpose of freeing switches from snow and ice during the past three winters at one of the busiest terminals in the country. The process is described as follows:

The melting of the snow or ice is effected by applying to it a flaming fluid of special character, which continued to burn while in the snow, melting and finally evaporating the greater portion of it. On account of the special character of the fluid, the flame is easily maintained regardless of the high winds of the storm or the drifting of the snow.

The fluid is applied by the regular track force by means of a safety distributing can, and the height and extent of the flame can be regulated with ease.

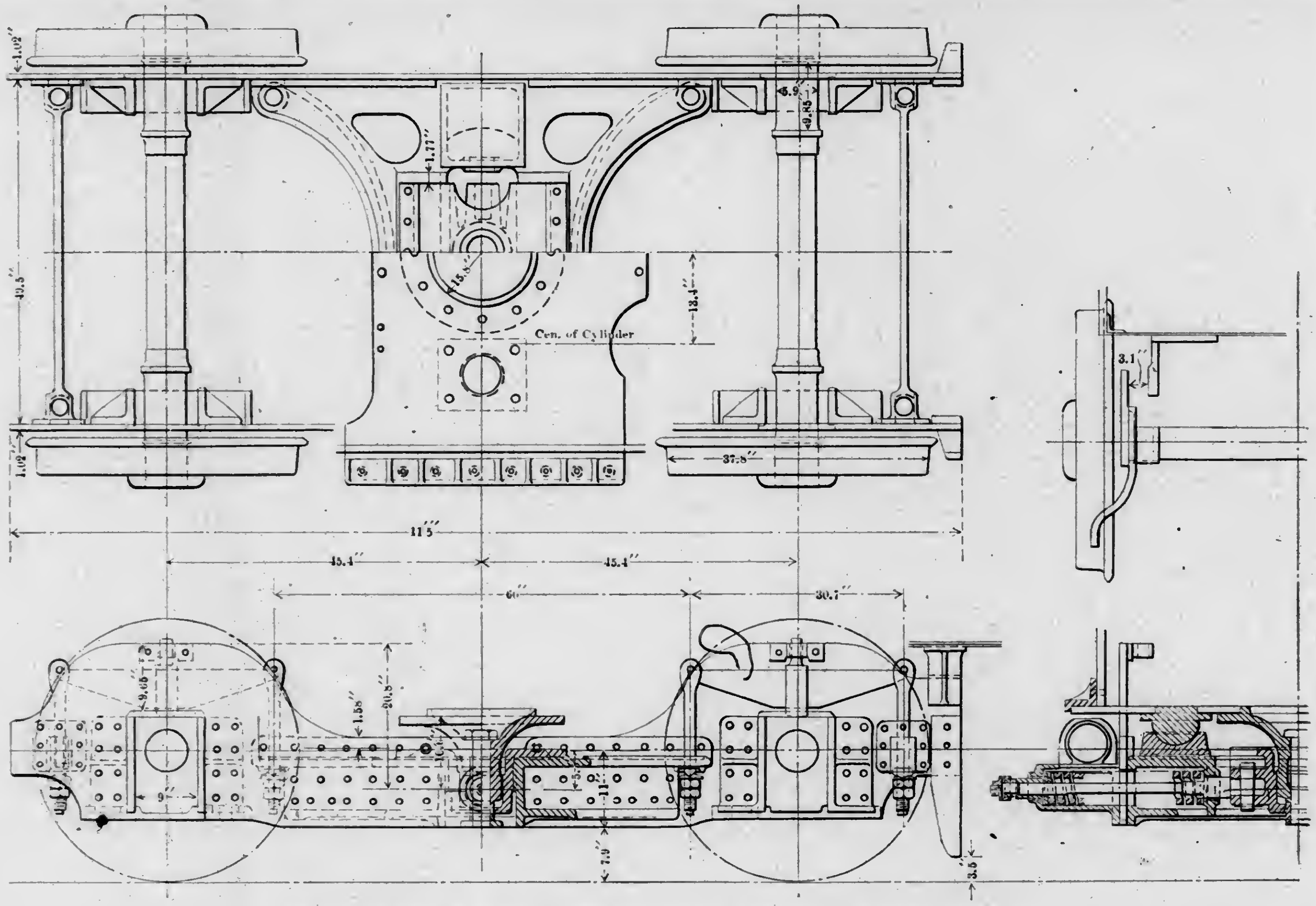
No injury to track results from the use of this system, as the temperature of the rails is not raised to the usual summer heat. The fluid is obtainable in the open market at from three to five cents per gallon and may be obtained free of cost by railroads operating their own Pintsch gas plant.

This system is said to be at once more economical and more effective than the common method of "hand cleaning" switches.

PROPOSED FREIGHT TUNNELS FOR NEW YORK CITY.—W. J. Wilgus, formerly vice-president of the New York Central & Hudson River R. R., and now president of the Amsterdam Corporation, of 165 Broadway, New York, has submitted to the Public Service Commission of that city an extensive plan whereby all the freight, mail, express and waste products of the business section of Manhattan are to be transported through underground railroads, which are to extend from several freight terminals to the basements of the shippers and receivers of merchandise. The plan is somewhat like that of the Chicago subways. The scheme contemplates a vast undertaking and is submitted for public discussion and the commission's approval. Mr. Wilgus states that should the project be approved the Amsterdam Corporation is prepared to submit a proposal by which it may be made effective through the granting of a franchise.

THE CUNARD LINER "LUSITANIA," by her westward voyage, completed July 11, achieved the distinction of being the first 25-knot steamer. She covered the long course from Daunt's Rock to Sandy Hook, of 3,891 miles, in 4 days, 19 hrs., 36 mins., an average speed of 25.01 knots per hour. A new record for the longest day's run was also made, 643 knots having been covered during the first day of the voyage. A readjustment of her propellers, which was made in Liverpool, is considered to have aided the ship to attain this speed. Two new forward propellers of four blades replaced the former three-bladed ones. They are solid castings of manganese bronze. The two rear propellers remain as before, with three blades. It is said that this arrangement also did away with all vibration.

DAILY RAILWAY AND ENGINEERING REVIEW.—During the week of the tenth annual convention of the Railway Engineering and Maintenance of Way Association, and the exhibit of the Road and Track Supply Association in Chicago, beginning March 15, 1909, *The Railway and Engineering Review* will issue a daily paper each morning, except Saturday.



ENGINE TRUCK—DE GLEHN COMPOUND LOCOMOTIVE—PARIS-ORLEANS RAILWAY.

DETAILS OF DEGLEHN COMPOUND LOCOMOTIVE.

PARIS-ORLEANS RAILWAY.

In the September issue of this journal, page 339, is given a general description, with illustrations, of some DeGlehn compound Pacific type locomotives which were recently delivered from the Schenectady Works of the American Locomotive Company to the Paris-Orleans Railway of France. In that article will be found also the drawings and a description of the cylinders and of a very novel design of boiler fitted to these locomotives.

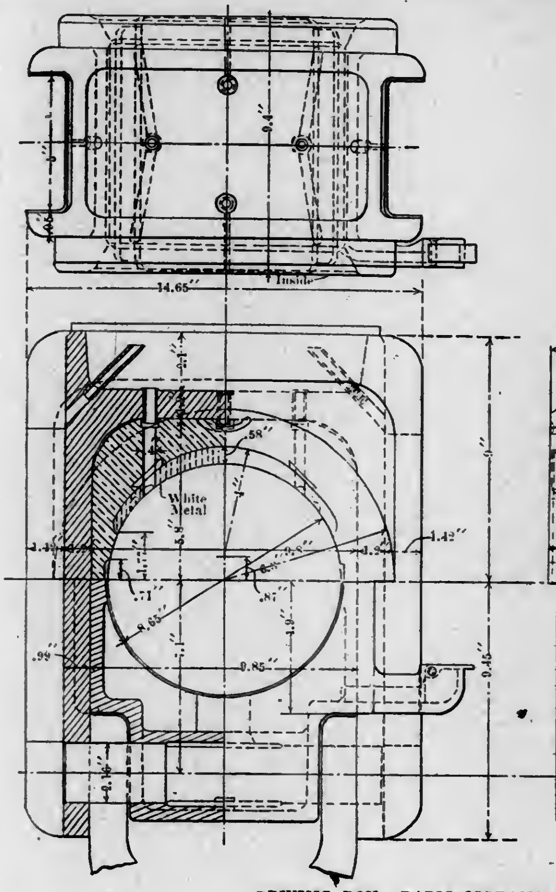
Although these engines were built in American works the design throughout is French and the drawings for use in the shops were dimensioned in the metric system. The drawings were furnished by the railway system and the locomotives are duplicates of a number which have been in service for some time. French locomotive designers have a reputation for painstaking care in details and in many respects their products form examples which American designers could follow to advantage, at least in cases where durability and efficiency are paramount.

Some of the more interesting of the detailed parts of these locomotives are shown in the accompanying illustrations and will be briefly described.

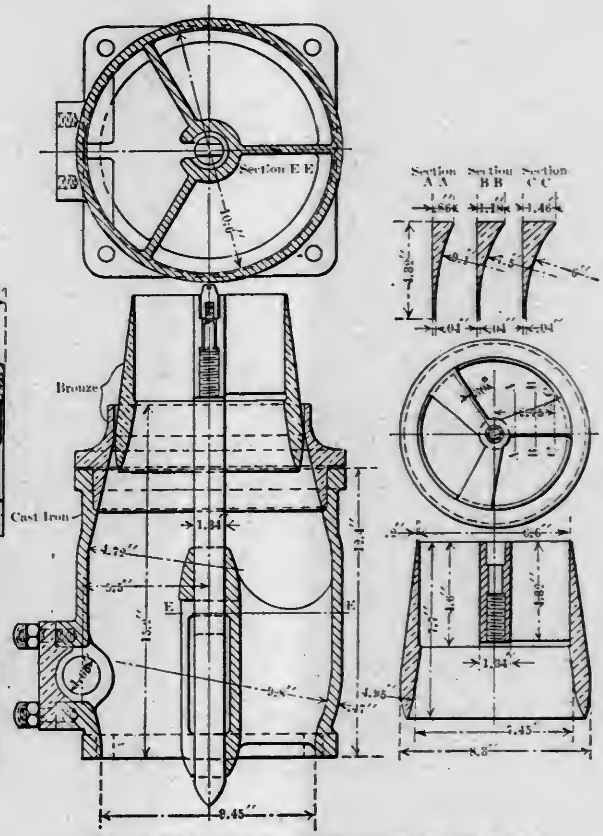
The engine truck is simple in arrangement, but contains features which are not known in American practice. On account of the low pressure cylinders being between the frames it is necessary to have the center bearing very low and the truck consists of side frames of about 1 in. steel and a cast steel center plate, settling well down between the axles, riveted to them. There are also connecting pieces outside of the pedestals for stiffening the side plates. The pedestals are riveted to the plate frames in the same manner as is used on the locomotive main frames. The center pin is secured to a plate fastened beneath the low pressure cylinders and to the locomotive frames and simply acts as a guide, not carrying any of the weight to the truck. This pin sets into a socket which fits in guides in the center plate and is held in position by a spring centering device, the arrangement of which is clearly shown in the illustration. The weight carried by the truck is transferred by two hemispherical bearings, which rest in bearing blocks, sliding upon the center plate. There are four semi-elliptical springs located over the top of the journal boxes and acting independently. At this point it will be noted that the spring is guided by an extension of the top of its center band, which fits into a guide bolted to the side frame. It will also be noted that the spring hangers are fitted with nuts at the bottom and hence the weight can be equalized on the different journals as necessary. The horn extending down in front of the front truck wheel, which is used abroad in place of the pilot, will be noticed in the illustration.

The driving boxes are of interest largely on account of their being constructed of hammered iron instead of cast iron or steel. The illustration shows the construction quite clearly and it will be seen that the brass slips into the box from the bottom and is not pressed in from the side as is the custom in this country. A white metal insert forms the larger part of the bearing area and unusual care has been given to distributing the lubricant both over the journal and to the hub plates and pedestals. The cellar is of cast iron and is held in place by the large bolt which supports the yoke from the springs, the springs being underhung. It will be noted that the cellar is provided with an extension for oiling and that it fits close to the journal on both sides. The driving boxes are casehardened on all bearing surfaces and form a very light and sensible design.

The pistons are interesting largely on account of their lightness, being constructed of hammered steel. Plain square packing rings, which are sprung into place and fitted with dowels to prevent turning, are used. The pistons are screwed on to the rod, having a taper fit. They are heated in boiling water before being fitted to the rod and after they are in place a pin hole is drilled and the pin driven through the head and rod and riveted



DRIVING BOX—PARIS-ORLEANS RY.

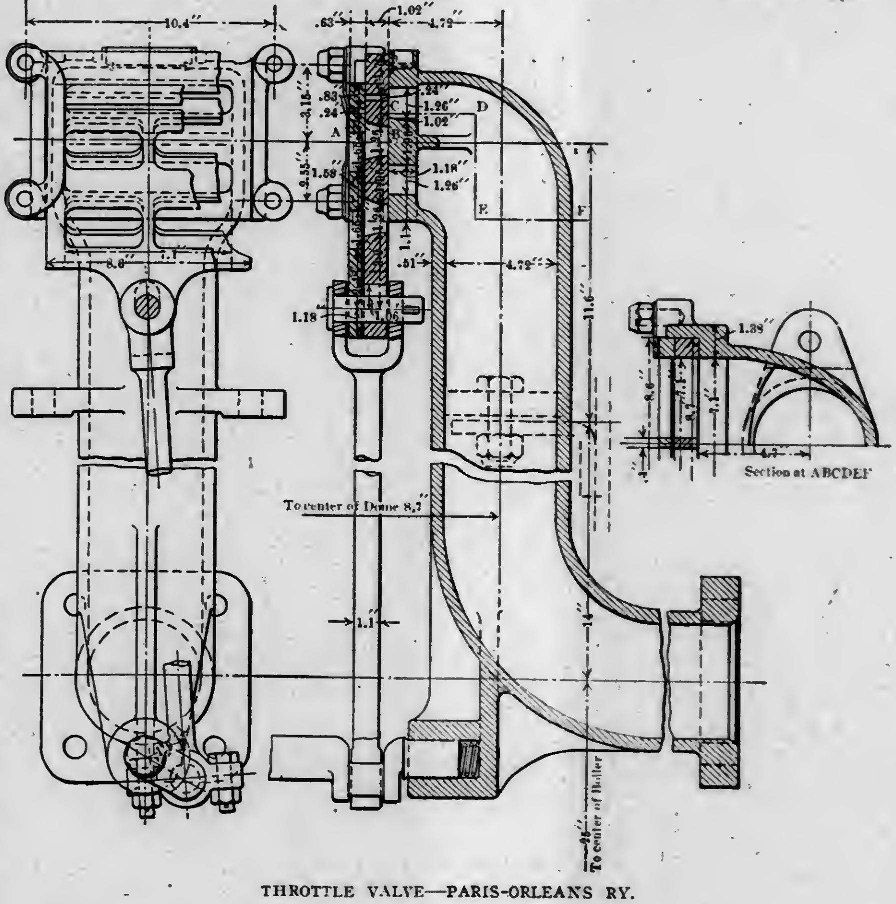


VARIABLE EXHAUST NOZZLE—PARIS-ORLEANS RY.

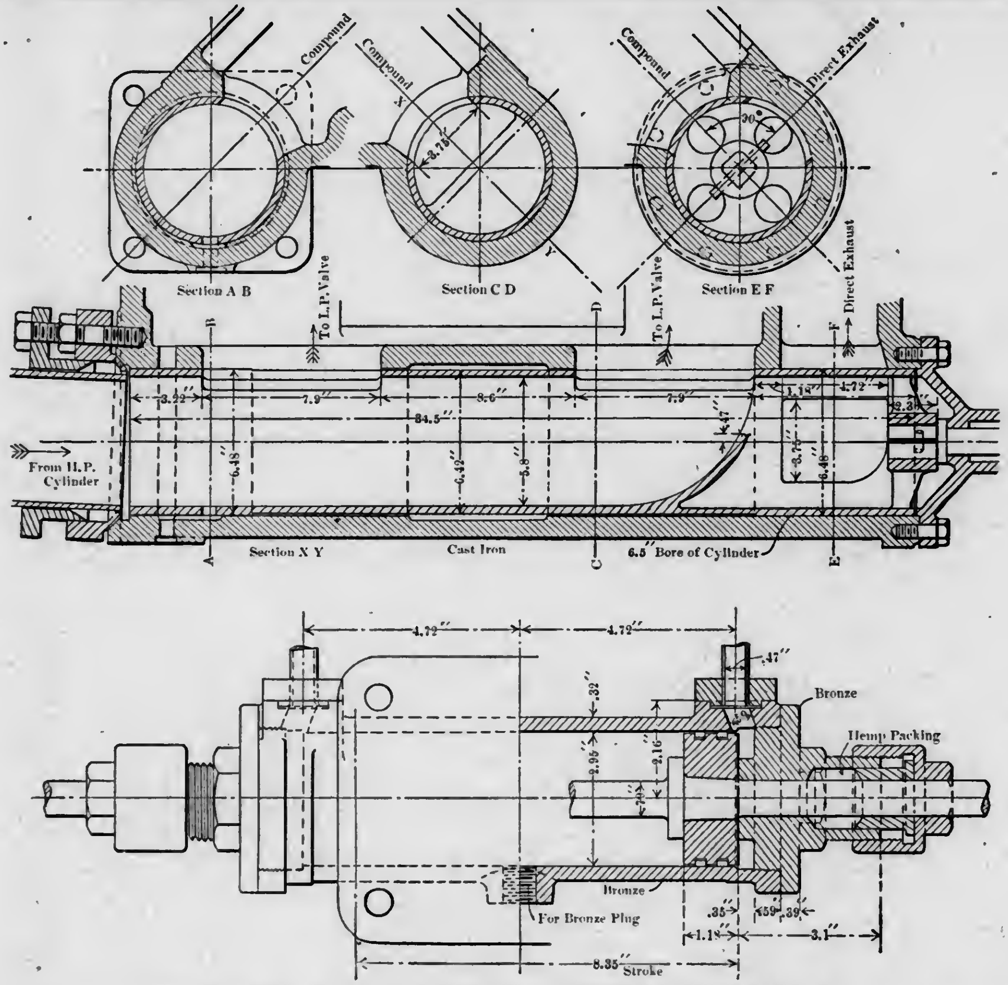
over on both sides. The piston head is about 1/8 of an inch smaller in diameter than the cylinder bore.

The gridiron type of throttle is used on these locomotives, and is shown in one of the illustrations. It requires no particular description and attention is simply called to the supplementary plate on the outside of the main throttle plate and the slotted connection in the latter, which is so arranged that when the throttle is in the position that would normally be called "cracked," only a slit about 1/4 in. wide admits steam. Further movement of the lever then throws both plates upward and gradually opens the ports, until finally when in a wide open position two slits measuring about 1 1/4 x 6 3/4 in., and giving and area of 17 sq. in., are exposed. The area of the standpipe at this point is but 11.2 sq. in. In closing the throttle the outer or supplementary plate moves first and gradually reduces the opening until the main plate comes into play. These grids are held in place by flat springs arranged as shown in the illustration. The throttle lever is, as mentioned in the description of the locomotive, located on the back head of the boiler and swings in a vertical instead of a horizontal plane. As can be seen, the movement on either side of the center or closed position will open the throttle valve.

The variable type of exhaust nozzle is in very general use on foreign railways, where its design has been very carefully worked out. The exhaust nozzle fitted to these locomotives is shown in one of the illustrations and consists of a bronze tip on a cast iron exhaust pipe within which is a supplementary bronze tip that can be raised and lowered by a connection extending out through the side of the smoke box and having a lever extending to the cab. The movable tip when in its highest position permits the steam to escape only through its center, which is arranged with three vanes and gives the escaping steam a whirling motion. When this tip is lowered, however, an outlet is given around its exterior surface and a cylindrical shaped jet of steam escapes around the inner whirling jet. The farther down the tip is drawn the larger area is given for the escape-



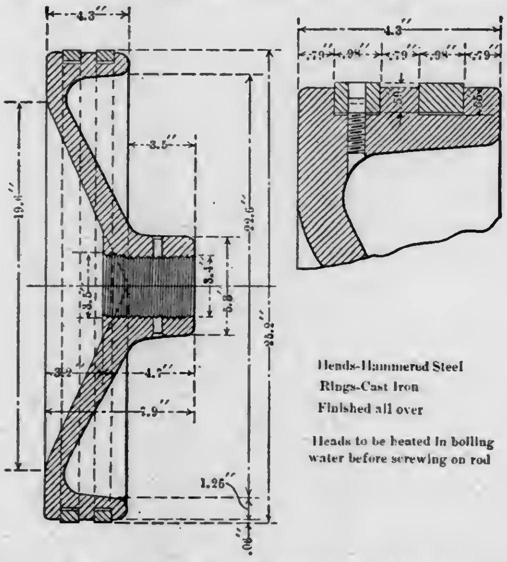
THROTTLE VALVE—PARIS-ORLEANS RY.



INTERCEPTING VALVE AND OPERATING CYLINDER—PARIS-ORLEANS RY.

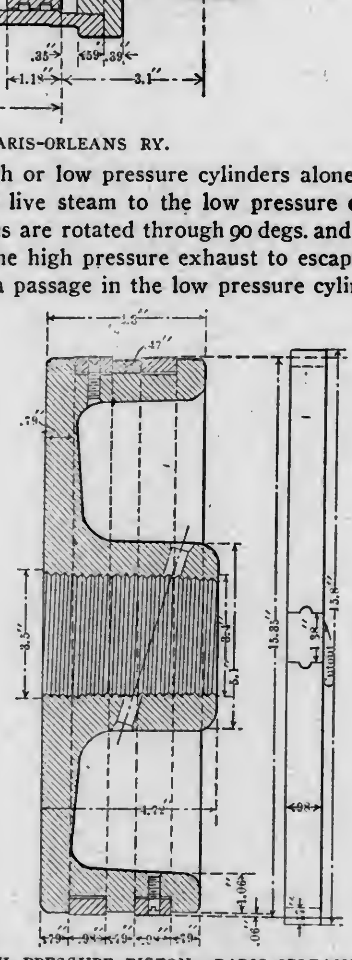
ing of the exhaust. The whirling motion given to the exhaust will permit it to fill a larger stack than it would if straight and also will tend to extinguish sparks by throwing them against the sides as they escape through the stack.

The intercepting valve and its operating cylinder are shown in one of the illustrations. The intercepting valve casing forms a part of the low pressure cylinder casting which extends outside of the main frames and the pipe carrying the exhaust from



LOW PRESSURE PISTON—PARIS-ORLEANS RY.

the high pressure cylinders enters at this point. The valves themselves are rotary, being formed in rights and lefts on the opposite side of the engine and simply consist of hollow cylindrical castings with ports cut at the proper points. They are connected by a shaft and lever arm to the operating cylinder, which sets across the engine just ahead of the low pressure cylinders. The arrangement is such that when it is desired to operate the high or low pressure cylinders alone or to admit reduced pressure live steam to the low pressure cylinders the intercepting valves are rotated through 90 degs. and the port is open which allows the high pressure exhaust to escape directly to the stack through a passage in the low pressure cylinder casting and



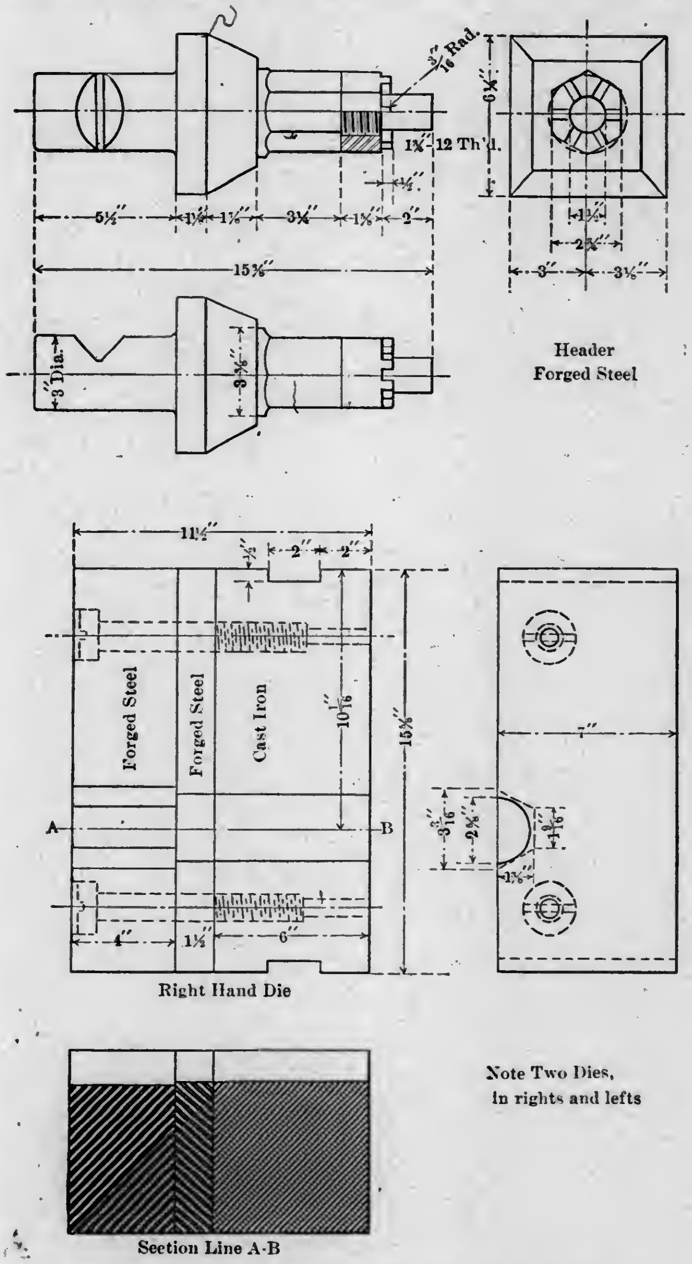
HIGH PRESSURE PISTON—PARIS-ORLEANS RY.

at the same time closes the passage to the low pressure valve chest. In this position the high pressure cylinders can be operated alone, the exhaust escaping as would a simple engine, or if desired, a supplementary valve admitting live steam to the low pressure cylinders, which has no connection to the intercepting valve, can be opened and the low pressure cylinders operated in that manner. The operating cylinder for the inter-

cepting valve, as can be seen, is the most simple design and can be operated by either steam or air through a three-way valve in the cab. Reference should be made to the illustrations showing the low pressure cylinders given on page 341 of the September issue, in this connection.

FORGING CASTLE NUTS.

Castle nuts, in sizes ranging from ¾ to 1¾ in., are made at the West Milwaukee shops of the Chicago, Milwaukee & St. Paul Railway on regular forging machines. The ¾ and 1 in. nuts are made on a 2 in. forging machine and the larger ones



DIES FOR FORGING CASTLE NUTS—C. M. & ST. P. RY.

on a 4 in. machine which is equipped with dies and a plunger, as shown in the accompanying illustration. Round bar stock is used, the bar being marked at the proper length to form the nut before being heated and the nut being forged on the end of the long bar, from which it is sheared off as soon as finished by a small shear forming part of the machine.

The nut is formed in one operation. After the two dies close up and hold the bar, the header or plunger comes forward, punching a hole of correct diameter for the tapping of the nut, which extends into the bar one-quarter of an inch beyond the thickness of the nut. The metal thus forced out of the center goes to fill up the hexagon and the extra one-quarter inch beyond the thickness of the nut assures the filling out of the extreme back corners. The header is equipped with bosses which form the slots for the spring cotters. After being sheared off from the stock bar the nut is ready for the tapping machine.

The part of the header which punches the nut and indents the slot is made of hardened tool steel and is arranged so that it can be unscrewed and renewals made at small expense.

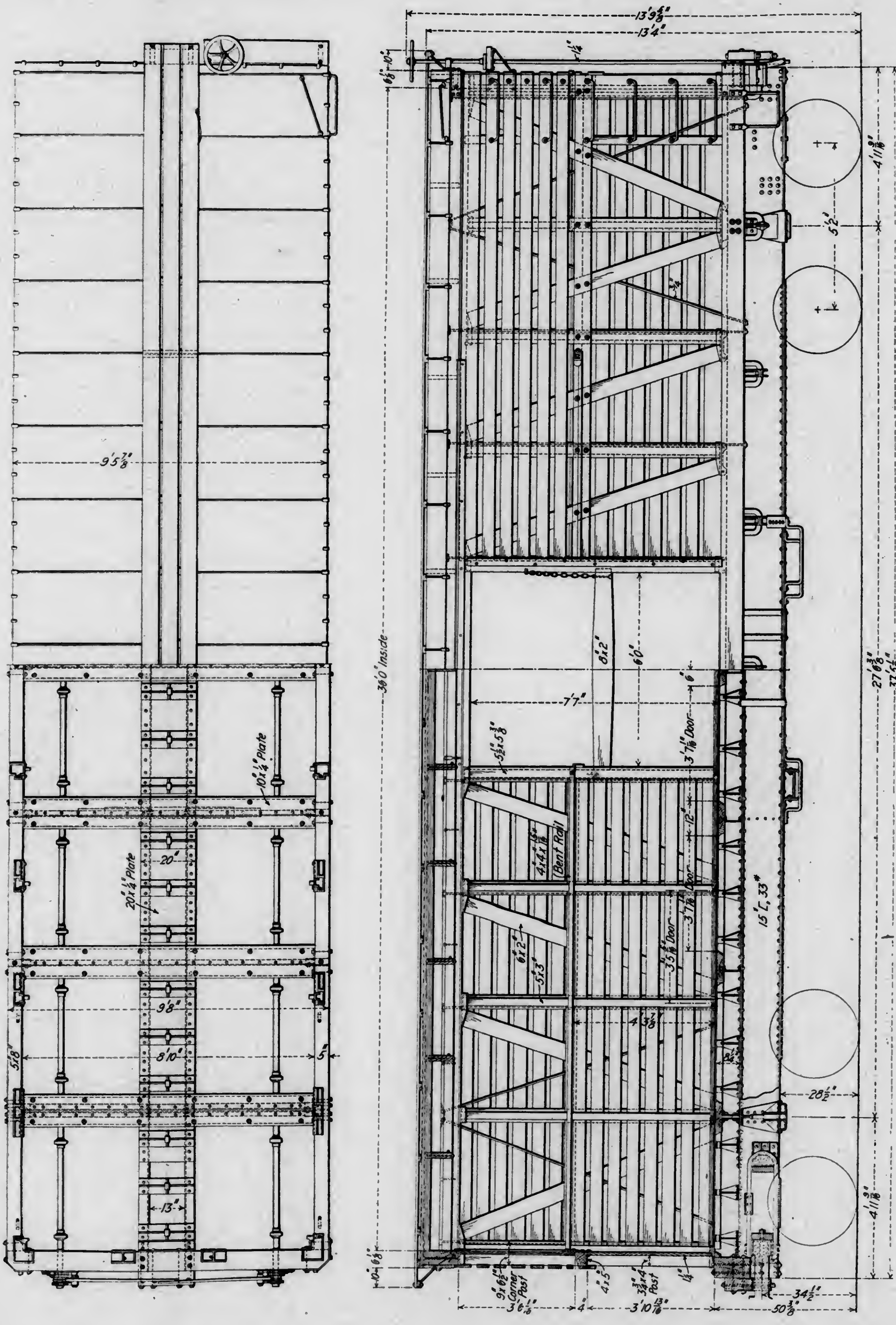
At present a 4 in. forging machine is turning out about two hundred 1¾ in. nuts per day of nine hours, smaller nuts being made at a faster rate.

A TRACK SUPPLY EXHIBITION.—The Road and Track Supply Association, which has heretofore made exhibits of track and structural materials and appliances in the parlors of the Auditorium Hotel, Chicago, during the annual convention of the Railway Engineering and Maintenance of Way Association in March of each year, will make its exhibit during the week beginning March 15, 1909, in the Coliseum building. The rooms and facilities in the hotel have been grossly inadequate for the purpose and inconvenient in every way except being in the same building with the convention. The Coliseum on Wabash avenue is especially adapted for exhibitions and is within reasonable distance of the hotel. A large amount of exhibit space has already been sold to manufacturers and dealers, the price being 40 cents per square foot, including booth, signs, etc. The minimum space will be 10 x 10 ft. The usual membership fee of $25 will also be charged, including three badges; extra badges $5 each. Application for space may be addressed to the secretary-treasurer, John N. Reynolds, 160 Harrison street, Chicago.

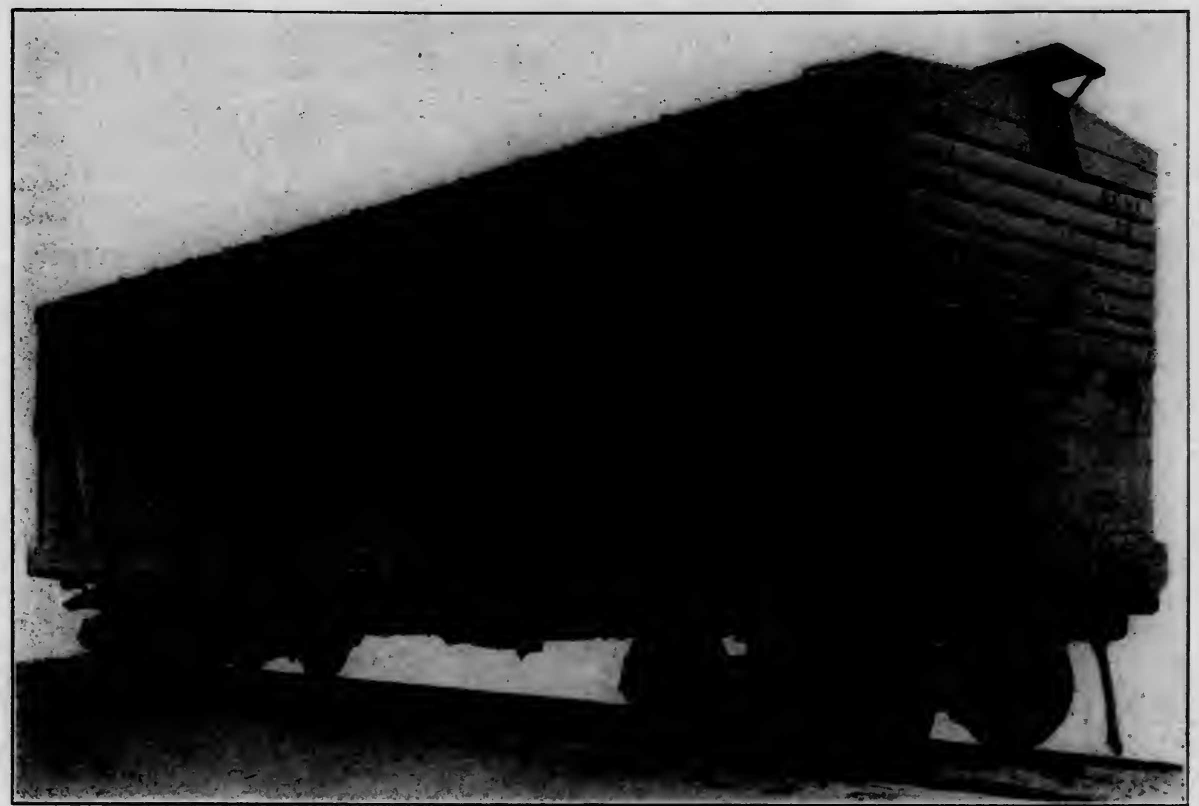
CASTLE NUTS BEFORE TAPPING—C. M. & ST. P. RY.

BRITISH RAILWAY ACCIDENTS IN 1907.—The annual Board of Trade return on railway accidents in the United Kingdom shows that 1,117 persons were killed and 8,811 injured by accidents due to the running of trains. These figures show a decrease of 52 in the number killed and an increase of 1,599 in the number injured, as compared with the totals for the previous year. Eighteen passengers were killed in train accidents, this number being below the average for the previous ten years. Eleven of these fatal accidents occurred in the disaster at Shrewsbury. The number of railway employees killed and injured in train accidents were 13 and 236 respectively; the number killed being the same as in the previous year, while the number injured shows an increase of 96. In the class of accidents caused by the movement of trains, exclusive of train accidents, 102 passengers were killed and 2,132 injured; a decrease of six in the number killed and an increase of 183 in the number injured, compared with 1906. It is remarked that the casualties to passengers in this class are much more numerous than those caused by train accidents, but they differ from the latter in this respect, that they mostly arise from the carelessness of the passengers themselves.

TRACK PRIZES ON THE P. R. R.—In accordance with a custom of long standing cash prizes aggregating $5,400 were awarded October 1 by the Pennsylvania R. R. to supervisors and assistant supervisors for excellence in track maintenance. The prizes range from $600 to $800 for supervisors and from $200 to $400 for the assistant supervisors.



THIRTY-TON GENERAL SERVICE CAR.



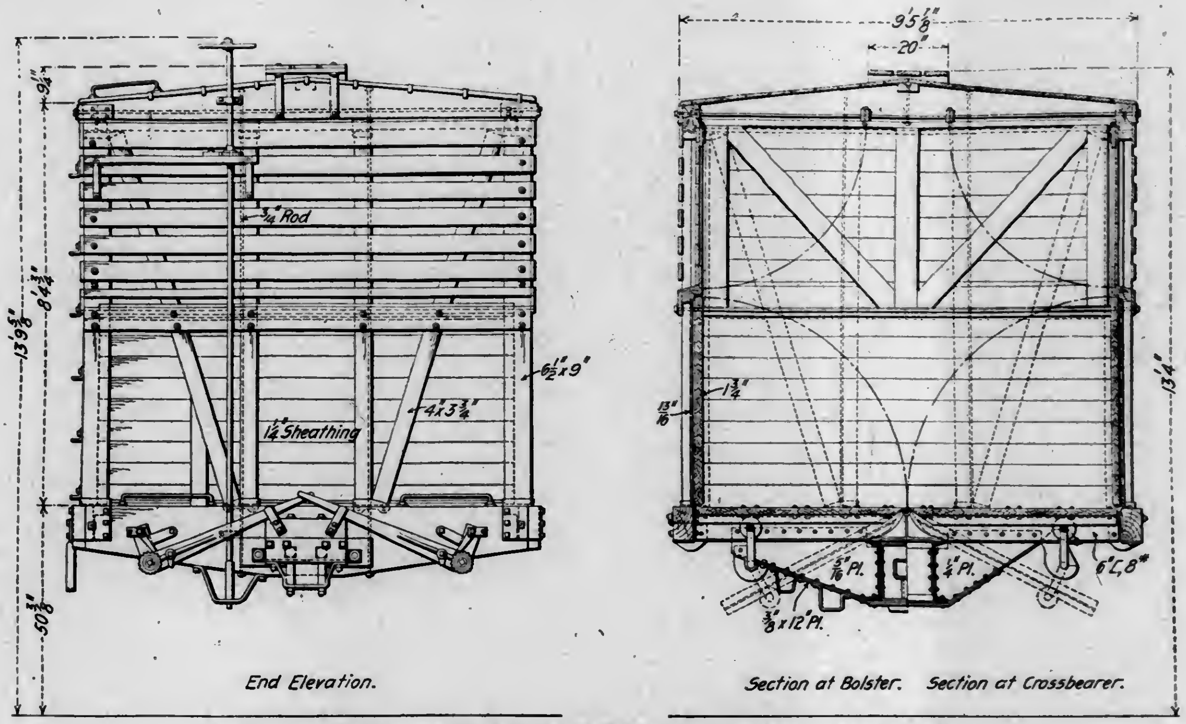
VIEW OF GENERAL SERVICE CAR WITH DROP DOORS RELEASED.

A GENERAL SERVICE FREIGHT EQUIPMENT CAR.

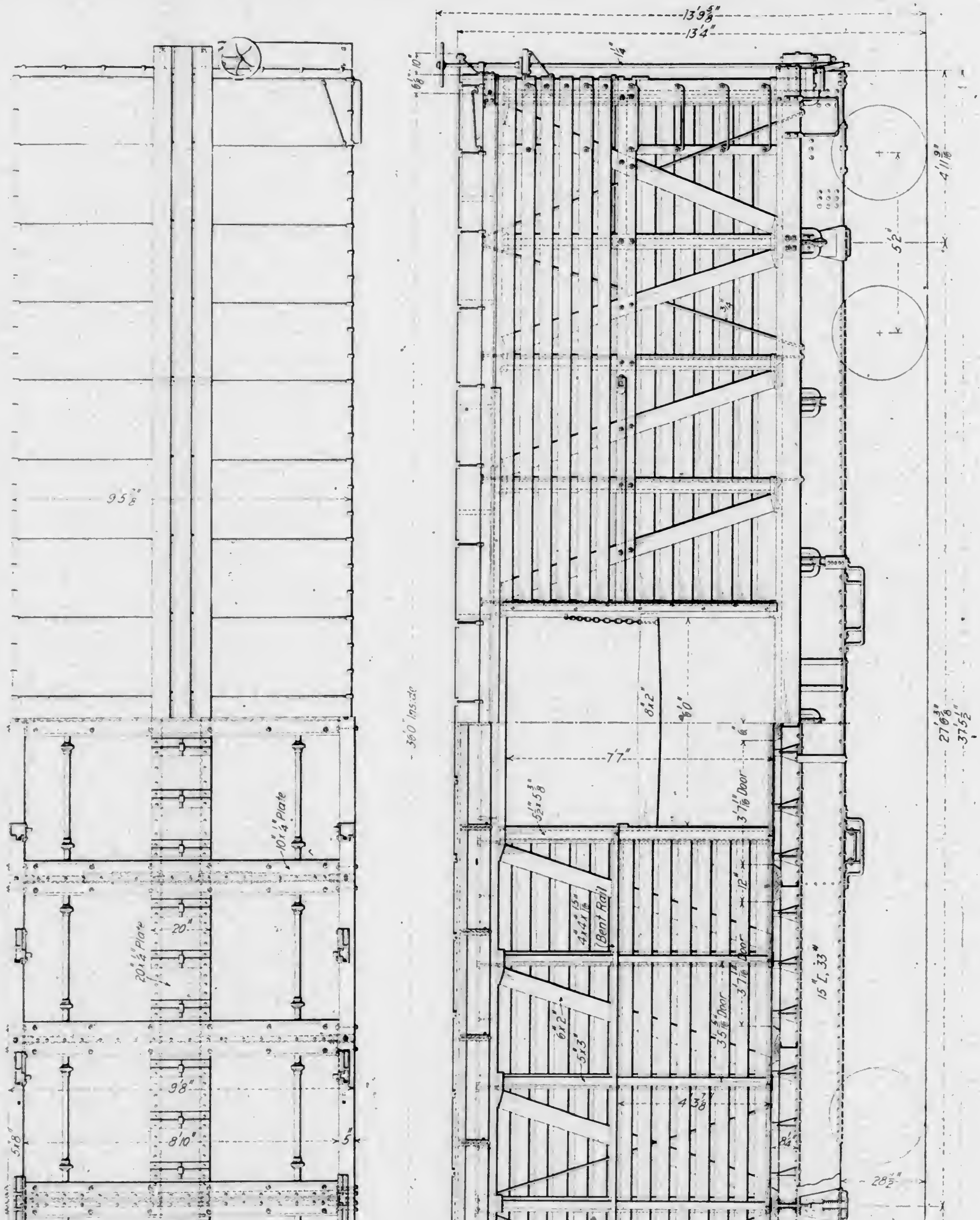
For the purpose of reducing empty car mileage, it is advisable to have freight equipment cars capable of and suitable for handling as many different classes of commodities as possible. The heaviest single kind of traffic, for which it is advisable to have specially adapted equipment on most of the railroads, moves in one direction only and if this equipment cannot be arranged to suit some other commodity for the return trip it must necessarily increase the empty car mileage and be a source of expense instead of revenue for a good portion of its life.

Visitors at the mechanical conventions at Atlantic City last June had an opportunity of inspecting a car which seems to carry the convertible idea to its greatest practical length. This car represents, first, a standard 30-ton stock car and as such does not differ in any essentials from the usual car, as far as the interior arrangement is concerned. It can then be converted into a covered gondola car with tight sides and floors and suitable for conveying any lading usually carried in gondola cars, which would pass through the doors. It can then further be converted into a perfectly tight and satisfactory box car. When arranged in either of the two latter forms it has the further advantage of being a drop bottom car, in which practically the whole of the floor area can be dropped and the lading discharged on either side of the track.

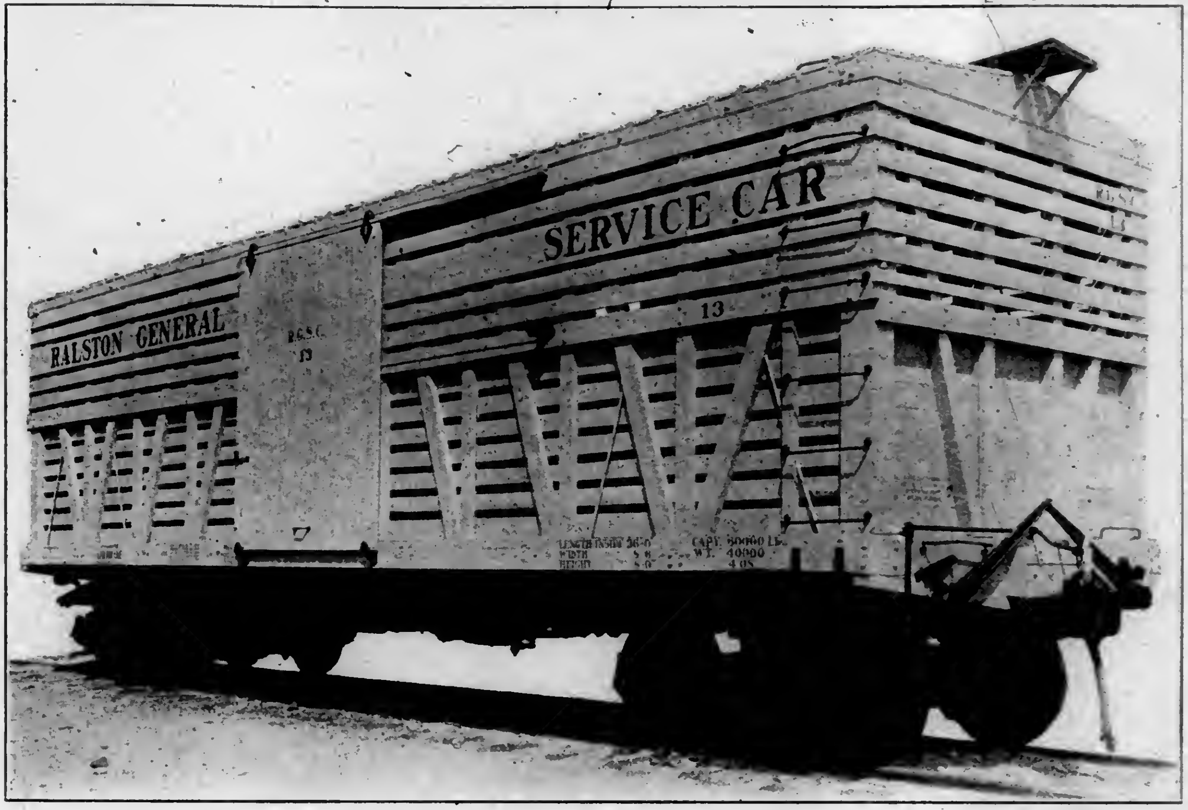
In construction the car is of the composite type, having an



END ELEVATION AND CROSS SECTION OF THIRTY-TON GENERAL SERVICE CAR.



THIRTY-TON GENERAL SERVICE CAR.



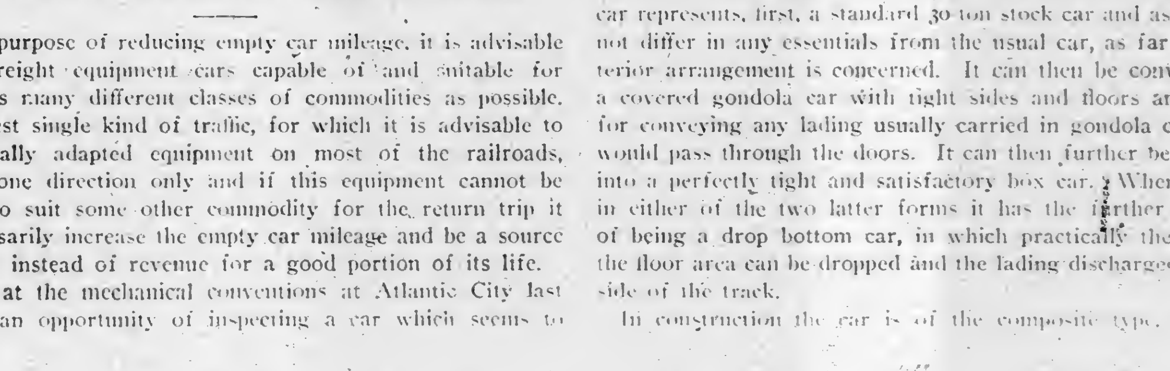
VIEW OF GENERAL SERVICE CAR WITH DROP DOORS RELEASED.

A GENERAL SERVICE FREIGHT EQUIPMENT CAR.

For the purpose of reducing empty car mileage, it is advisable to have freight equipment cars capable of and suitable for handling as many different classes of commodities as possible. The heaviest single kind of traffic, for which it is advisable to have specially adapted equipment on most of the railroads, moves in one direction only and if this equipment cannot be arranged to suit some other commodity for the return trip it must necessarily increase the empty car mileage and be a source of expense instead of revenue for a good portion of its life.

Visitors at the mechanical conventions at Atlantic City last June had an opportunity of inspecting a car which seems to carry the convertible idea to its greatest practical length. This car represents, first, a standard 30 ton stock car and as such does not differ in any essentials from the usual car, as far as the interior arrangement is concerned. It can then be converted into a covered gondola car with tight sides and floors and suitable for conveying any lading usually carried in gondola cars, which would pass through the doors. It can then further be converted into a perfectly tight and satisfactory box car. When arranged in either of the two latter forms it has the further advantage of being a drop bottom car, in which practically the whole of the floor area can be dropped and the lading discharged on either side of the track.

In construction the car is of the composite type, having an



END ELEVATION AND CROSS SECTION OF THIRTY-TON GENERAL SERVICE CAR.

INTERIOR VIEW OF GENERAL SERVICE CAR FOR USE AS GONDOLA.

all-steel underframe and a wooden superstructure including side and end sills. The underframe is constructed so as to take all of the shocks of service and the superstructure is required to carry simply the strains due to shifting loads and its own weight and momentum.

The underframe is of the same general type as is furnished by the builders of this car, the Ralston Steel Car Co., for application under present wooden equipment, or as a foundation for equipment for composite freight cars of any type, and consists of a heavy box girder type of center sill, built up of two 15 in., 33 lb., channels, set 13 in. apart, having a ¼ in. cover plate on top extending the full length of the car and a similar cover plate on the bottom extending nearly to the bolsters. The two channels are notched at either end and the web is bent down, forming a shelf for supporting the wooden end sills of the car. The draft castings are riveted directly to the web of the center sill channels and convey their stresses through a point slightly below the neutral axis of the girder. The construction of the underframe is such as to throw all of the weight of the car, as well as the pulling and buffing stresses, to this center sill, which is evidently of sufficient size and strength to take care of them.

The body bolster consists of four flanged steel plates or diaphragms, 5/16 in. in thickness, riveted to the webs of the center sills and secured at the top to two 6 in., 8 lb., channels extended across the top of the center sill, and forming the tension member of the bolster. A ⅜ in. cover plate, passing underneath the center sills, is riveted to the flanges on the diaphragm plates and to the spacing casting between the center sills. The 6 in. channels carry a hanger casting at either end, in which the 5 x 8 in. wooden side sills are secured. A ¼ in. cover plate on top of the channels completes the bolster construction, which is evidently of more than ordinary strength. The five cross bearers between the bolsters are composed of 6 in., 8 lb., channels resting on top of the center sills in the same manner as at the bolsters. Two of these, near the center of the car, are reinforced by flanged diaphragms riveted to the center sill channels, as is shown in one of the cross sections. The cross bearers have a 10 x ¼ in. cover plate extended the width of the car and forming the floor between the drop doors.

The wooden superstructure is of the usual construction of a standard stock car, as far as the framework is concerned. The floor consists first of sixteen sections, each one forming a drop door, being hinged above the center sills, which, when in a raised position, form a perfectly flat and comparatively tight floor. When used as a stock car there is another floor consisting of 16 sections, which are hinged along the sides above the side sills and are dropped down, matching in the center and forming a perfectly level floor. When it is desired to enclose the lower half of the car for use as a gondola, these sections are raised and fastened along the sides, forming a car which may be used for coal, coke, brick or similar lading. If used as a box car the sections, shown in the illustration as secured under the carlins, are dropped down and, fitting into place, completely enclose the car.

The drop door system is operated by the well-known Ralston type of crank shafts operated by a lever and ratchet at the end of the car. In this case there are four levers, each one operating four doors. When the doors are closed they are held in place by automatic gravity locks, which are positive in their action. These locks carry no strains and are simply to prevent the shaft shaking loose in transit. In addition to the gravity locks at the end there are also locks on the opposite end of the shaft at the center of the car. The arrangement of the drop doors and other operating mechanism is shown in the illustration.

The car weighs 40,000 lbs., is 36 ft. long inside and has a capacity of 60,000 lbs. The side doors can be of any type desired and the trucks are furnished as specified.

Skill in Handling the Reverse Lever and Throttle gets as many heavy trains in on time as big locomotives carrying a high steam pressure. Skill with the injector counts for as much as skill with the scoop if the steam gauge is any guide.—*C. B. Conger before the Traveling Engineers' Association.*

RAILWAY BUSINESS ASSOCIATION.

An important meeting of the manufacturers of railroad material and equipment was held at the Waldorf-Astoria, New York City, on the evening of September 30 for the purpose of forming a permanent organization whose object should be to obtain united action in systematic efforts for the conservation of the interests of the railroads. The Association, called the "Railroad Business Association," was formally organized and the following officers elected: George A. Post, president; H. H. Westinghouse, O. H. Cutler, W. H. Marshall, E. S. S. Keith, A. H. Mulliken, O. P. Letchworth, vice-presidents; Charles A. Moore, treasurer, and W. P. Pearce, William V. Kelley, Col. H. G. Prout, J. S. Coffin, N. Paul Fenner, E. L. Adreon, J. H. Schwacke, A. M. Kittredge and John F. Deckson, executive committee.

It was thoroughly impressed upon all of those present that this association is strictly non-partisan; it has, and is to have, nothing at all to do with politics. It has no axe to grind other than to see that fair play is given to the railroads. It does not attempt to excuse the misdeeds of railways, but exists for the purpose of attempting to guide and form public opinion so that the railways will be accorded the credit due them from the public and be given a chance to counteract the results of the work of the demagogue and agitator. The reasons for an organization of this kind are best given by some extracts from the address delivered by George A. Post, president of the Standard Coupler Company, who acted as temporary chairman of the meeting. He stated in part:

When railroads are prosperous, times are good everywhere; when railroads are not prosperous, jobless hordes are in despair, and the cupboards of workingmen are bare. Largely responsible for this paralysis afflicting our railroads is the attitude of harsh hostility toward them, as manifested in federal and state administrative and legislative circles. Because of this hostility, confidence of investors in their prospective profitable operations, and in the stability of values of their securities has been seriously undermined.

To denounce railroads and railroad officers, and to scheme for their discomfiture, has become epidemic among many people otherwise rational. So persistent has been the indiscriminate condemnation of railroad managers, that it has come to be considered a necessary ingredient of the vocal output of those who seek popular favor to gain political preferment. In the absence of any other qualification for the exercise of political power, the aspirant has deemed it sufficient to declaim vehemently against railroads and to give assurance that condign punishment shall be meted out by him, if elected, to those who control the means of transportation. No legislative anti-corporation bomb could be too deadly to please people who are frenzied in their opposition thereto.

* * * * * * * * * * *

To attain the knowledge and experience wherewith properly and successfully to operate a railroad is a tedious process. The preliminary training covers many years of patient toil and profound study of the subject, and is then only possible of attainment by those of a high order of intelligence. And yet, it has come to pass in this era of hysteria that such men and their views regarding railroad operations are tabooed. The popular conception of the true railroad scientist is one who never spent a day of his life in railroad service, but whose mental activities have been applied in other occupations far removed from the possibility of acquiring railroad knowledge. It is a peculiar fact that a trained railroad man will frankly disavow any knowledge of how to conduct any other business, but you seldom find a man running any other kind of business, whether successfully or otherwise, who does not consider himself a competent critic of railroad management.

The railroads of America are just now the victims of a powerful and vindictive wrath trust. We hear much of the depredations of trust magnates, and the injustice and oppressions of predatory wealth. But what of the devastating attacks of "predatory wrath" upon railroads? There has been an amalgamation of all the small local hostilities to railroads that have been started—here through the peevishness of some station agent, there through the brusque manners of an uncivil train man, elsewhere by the avarice of some wicked stock jobber, or, in some quarters, by the frosty pomposity of some railroad executive. These wrath factories have poisoned the minds of whole communities, and sharp-tongued representatives have enlisted the antagonism of counties. Ignited by the fiery objurgation of excited orators, states have become mammoth furnaces wherein discontent has seethed, hissed and blazed. From these fires of wrath, sparks in the shape of ambitious, cunning, self-seekers have been shot into the municipal, county, state and federal councils, there to set fire to the imagination, the hopes, the fears, and cupidity of the populace, and to hurl fire-brands of inimical legislation into the camps of the railroads. Onward has spread the work of consolidation.

* * * * * * * * * * *

It has been a great, fat feast for predatory wrath makers. They have roamed abroad throughout the land, putting crimps in railroads that make them writhe in the agonies of depleted revenues and that have emptied the dinner pails of an army of railroad employees.

No trust that was ever organized in this country has it in its power to create the thousandth part of the havoc, rob so many people of employment, strike terror to the hearts of investors and diminish the incomes of widows and orphans as has this same juggernaut of agitation—the wrath trust.

Its vengeful progress must be checked. The hour has struck when courageous men must form a wall of human adamant and resist it. If ever again good times shall return to bless us; if ever again we may boast of American prosperity; if ever again confidence shall be restored in business circles, there must be an end to this frenzied fulmination against railroads, and calm reason must bear sway in the solution of the intricate problems that confront us.

* * * * * * * * * * *

In any dispute the right is seldom all on one side. All the zeal for gain and commercial advantage in this country is not confined to those who manage our railroads. Every shipper is not a saint, nor is every common carrier a demon. Not every complaint lodged against a railroad is founded in truth and equity. A large percentage of the hue and cry against railroads is simply the vaporings of chronic growlers, who growl at railroads as they growl at their neighbors, or find fault with their family's expenditures.

It is true beyond a doubt that there have been in the past and are at present many things in the conduct of our railroads that were not and are not right, and against which protest has been and may be rightly made. To deny this would be silly, and would render abortive at their inception any efforts that we might make in behalf of railroads. If we would be influential in our friendship for the railroads, our attitude must not be that of condonation of any wrong, but staunch advocacy of fair play all round. We are manufacturers of railroad materials, not vendors of taffy.

There is serious work to be done. We want orders. We want to see the fires lighted in our furnaces, profits flowing into our coffers, workingmen made glad by the joyous sound of the shop whistles calling them from idleness to work. Not one of these hopes can be realized until railroads are relieved of the incubus of hostile agitation that now halts their successful operation.

It is admitted that some reforms are necessary and desirable in the conduct of railroads, to the end that discontent may be quieted. It is conceded that as public servants, exercising the great powers conferred upon them by the people, intended for the public good, and possessed of franchises of untold value, granted them by legislation, railroads should be subjected to proper regulation and supervision by the people through constituted authority. But there is a vast difference between healthful, sane regulation and vicious strangulation. Not every carping critic is a Solomon; nor is every lawmaker a statesman. Because a law is aimed at a railroad does not necessarily make it right or expedient; it may be wrong and work injustice. Hot-headed legislators enact hot-headed legislation. Statutes conceived in wrath have their fruition in paralyzed commerce. As abaters of the smoke nuisance they have our inventors in that line lashed to the mast.

* * * * * * * * * * *

The thoroughly trained, capable and honest officials, whose energies and brains are concentrated upon the problem of conducting the business of railroads profitably to their owners and satisfactorily to their patrons, should be upheld and their work appreciated. They are, in fact, the overwhelming majority.

Those railroad officials who vex the public by temperamental failings, who are brusque and inconsiderate in their intercourse with the public, must be brought to realize that they are in fact public servants and not monarchs.

Those who may be guilty of wicked practices, in the administration of railroad properties, should be scourged with the lash of universal scorn and driven from the railroad field.

Those who decry railroads with malicious intent; who would cripple them to gratify personal spleen, or for personal aggrandizement, must be exposed and their power for evil destroyed.

Those who criticize railroad methods intelligently; who have just cause for complaint in their dealings with railroads, must be accorded respectful audience and be listened to with ears anxious for the truth.

Those who depend upon railroads for subsistence, directly or indirectly, must be loyal to their means of support, and quick to resent interference therewith by crafty or turbulent trouble makers.

Railroads must be operated with a fair margin of profit, else they cannot maintain efficiency in equipment, adequately meet increasing demands for terminal facilities and other betterments, nor can they pay good wages to their operatives. In other business enterprises, it is a maxim that prices include a profit. If there are no profits, there is bankruptcy. There is no reason why transportation rates should not be adjusted upon the same basis.

* * * * * * * * * * *

All these things can be accomplished. They must be accomplished. Who are better equipped than bodies of men such as are here assembled, to aid in their accomplishment?

CAR SHORTAGE ON C. P. R.—In a special report by the president of the Canadian Pacific, he said that during the last six years the company had spent $37,000,000 for locomotives and cars, and yet during the next six weeks there would hardly be enough cars to handle the business offered.

INTERIOR VIEW OF GENERAL SERVICE CAR FOR USE AS GONDOLA.

all-steel underframe and a wooden superstructure including side and end sills. The underframe is constructed so as to take all of the shocks of service and the superstructure is required to carry simply the strains due to shifting loads and its own weight and momentum.

The underframe is of the same general type as is furnished by the builders of this car, the Ralston Steel Car Co., for application under present wooden equipment, or as a foundation for equipment for composite freight cars of any type, and consists of a heavy box girder type of center sill, built up of two 15 in., 33 lb., channels, set 13 in. apart, having a ¼ in. cover plate on top extending the full length of the car and a similar cover plate on the bottom extending nearly to the bolsters. The two channels are notched at either end and the web is bent down, forming a shelf for supporting the wooden end sills of the car. The draft castings are riveted directly to the web of the center sill channels and convey their stresses through a point slightly below the neutral axis of the girder. The construction of the underframe is such as to throw all of the weight of the car, as well as the pulling and buffing stresses, to this center sill, which is evidently of sufficient size and strength to take care of them.

The body bolster consists of four flanged steel plates or diaphragms, 5/16 in. in thickness, riveted to the webs of the center sills and secured at the top to two 6 in., 8 lb., channels extended across the top of the center sill, and forming the tension member of the bolster. A ⅜ in. cover plate, passing underneath the center sills, is riveted to the flanges on the diaphragm plates and to the spacing casting between the center sills. The 6 in. channels carry a hanger casting at either end, in which the 5 x 8 in. wooden side sills are secured. A ¼ in. cover plate on top of the channels completes the bolster construction, which is evidently of more than ordinary strength. The five cross bearers between the bolsters are composed of 6 in., 8 lb., channels resting on top of the center sills in the same manner as at the bolsters. Two of these, near the center of the car, are reinforced by flanged diaphragms riveted to the center sill channels, as is shown in one of the cross sections. The cross bearers have a 10 x ¼ in. cover plate extended the width of the car and forming the floor between the drop doors.

The wooden superstructure is of the usual construction of a standard stock car, as far as the framework is concerned. The floor consists first of sixteen sections, each one forming a drop door, being hinged above the center sills, which, when in a raised position, form a perfectly flat and comparatively tight floor. When used as a stock car there is another floor consisting of 16 sections, which are hinged along the sides above the side sills and are dropped down, matching in the center and forming a perfectly level floor. When it is desired to enclose the lower half of the car for use as a gondola, these sections are raised and fastened along the sides, forming a car which may be used for coal, coke, brick or similar lading. If used as a box car the sections, shown in the illustration as secured under the carlins, are dropped down and, fitting into place, completely enclose the car.

The drop door system is operated by the well-known Ralston type of crank shafts operated by a lever and ratchet at the end of the car. In this case there are four levers, each one operating four doors. When the doors are closed they are held in place by automatic gravity locks, which are positive in their action. These locks carry no strains and are simply to prevent the shaft shaking loose in transit. In addition to the gravity locks at the end there are also locks on the opposite end of the shaft at the center of the car. The arrangement of the drop doors and other operating mechanism is shown in the illustration.

The car weighs 40,000 lbs., is 36 ft. long inside and has a capacity of 60,000 lbs. The side doors can be of any type desired and the trucks are furnished as specified.

Skill in Handling the Reverse Lever and Throttle gets as many heavy trains in on time as big locomotives carrying a high steam pressure. Skill with the injector counts for as much as skill with the scoop if the steam gauge is any guide.—*C. B. Conger before the Traveling Engineers' Association.*

RAILWAY BUSINESS ASSOCIATION.

An important meeting of the manufacturers of railroad material and equipment was held at the Waldorf-Astoria, New York City, on the evening of September 30 for the purpose of forming a permanent organization whose object should be to obtain united action in systematic efforts for the conservation of the interests of the railroads. The Association, called the "Railroad Business Association," was formally organized and the following officers elected: George A. Post, president; H. H. Westinghouse, O. H. Cutler, W. H. Marshall, E. S. S. Keith, A. H. Mulliken, O. P. Letchworth, vice-presidents; Charles A. Moore, treasurer, and W. P. Pearce, William V. Kelley, Col. H. G. Prout, J. S. Coffin, N. Paul Fenner, E. L. Adreon, J. H. Schwacke, A. M. Kittredge and John F. Deckson, executive committee.

It was thoroughly impressed upon all of those present that this association is strictly non-partisan; it has, and is to have, nothing at all to do with politics. It has no axe to grind other than to see that fair play is given to the railroads. It does not attempt to excuse the misdeeds of railways, but exists for the purpose of attempting to guide and form public opinion so that the railways will be accorded the credit due them from the public and be given a chance to counteract the results of the work of the demagogue and agitator. The reasons for an organization of this kind are best given by some extracts from the address delivered by George A. Post, president of the Standard Coupler Company, who acted as temporary chairman of the meeting. He stated in part:

When railroads are prosperous, times are good everywhere; when railroads are not prosperous, jobless hordes are in despair, and the cupboards of workingmen are bare. Largely responsible for this paralysis afflicting our railroads is the attitude of harsh hostility toward them, as manifested in federal and state administrative and legislative circles. Because of this hostility, confidence of investors in their prospective profitable operations, and in the stability of values of their securities has been seriously undermined.

To denounce railroads and railroad officers, and to scheme for their discomfiture, has become epidemic among many people otherwise rational. So persistent has been the indiscriminate condemnation of railroad managers, that it has come to be considered a necessary ingredient of the vocal output of those who seek popular favor to gain political preferment. In the absence of any other qualification for the exercise of political power, the aspirant has deemed it sufficient to declaim vehemently against railroads and to give assurance that condign punishment shall be meted out by him, if elected, to those who control the means of transportation. No legislative anti-corporation bomb could be too deadly to please people who are frenzied in their opposition thereto.

* * * * * * * * * *

To attain the knowledge and experience wherewith properly and successfully to operate a railroad is a tedious process. The preliminary training covers many years of patient toil and profound study of the subject, and is then only possible of attainment by those of a high order of intelligence. And yet, it has come to pass in this era of hysteria that such men and their views regarding railroad operations are tabooed. The popular conception of the true railroad scientist is one who never spent a day of his life in railroad service, but whose mental activities have been applied in other occupations far removed from the possibility of acquiring railroad knowledge. It is a peculiar fact that a trained railroad man will frankly disavow any knowledge of how to conduct any other business, but you seldom find a man running any other kind of business, whether successfully or otherwise, who does not consider himself a competent critic of railroad management.

The railroads of America are just now the victims of a powerful and vindictive wrath trust. We hear much of the depredations of trust magnates, and the injustice and oppressions of predatory wealth. But what of the devastating attacks of "predatory wrath" upon railroads? There has been an amalgamation of all the small local hostilities to railroads that have been started—here through the peevishness of some station agent, there through the brusque manners of an uncivil train man, elsewhere by the avarice of some wicked stock jobber, or, in some quarters, by the frosty pomposity of some railroad executive. These wrath factories have poisoned the minds of whole communities, and sharp-tongued representatives have enlisted the antagonism of counties. Ignited by the fiery objurgation of excited orators, states have become mammoth furnaces wherein discontent has seethed, hissed and blazed. From these fires of wrath, sparks in the shape of ambitious, cunning, self-seekers have been shot into the municipal, county, state and federal councils, there to set fire to the imagination, the hopes, the fears, and cupidity of the populace, and to hurl fire-brands of inimical legislation into the camps of the railroads. Onward has spread the work of consolidation.

* * * * * * * * * *

It has been a great, fat feast for predatory wrath makers. They have roamed abroad throughout the land, putting crimps in railroads that make them writhe in the agonies of depleted revenues and that have emptied the dinner pails of an army of railroad employees.

No trust that was ever organized in this country has it in its power to create the thousandth part of the havoc, rob so many people of employment, strike terror to the hearts of investors and diminish the incomes of widows and orphans as has this same juggernaut of agitation—the wrath trust.

Its vengeful progress must be checked. The hour has struck when courageous men must form a wall of human adamant and resist it. If ever again good times shall return to bless us; if ever again we may boast of American prosperity; if ever again confidence shall be restored in business circles, there must be an end to this frenzied fulmination against railroads, and calm reason must bear sway in the solution of the intricate problems that confront us.

* * * * * * * * * *

In any dispute the right is seldom all on one side. All the zeal for gain and commercial advantage in this country is not confined to those who manage our railroads. Every shipper is not a saint, nor is every common carrier a demon. Not every complaint lodged against a railroad is founded in truth and equity. A large percentage of the hue and cry against railroads is simply the vaporings of chronic growlers, who growl at railroads as they growl at their neighbors, or find fault with their family's expenditures.

It is true beyond a doubt that there have been in the past and are at present many things in the conduct of our railroads that were not and are not right, and against which protest has been and may be rightly made. To deny this would be silly, and would render abortive at their inception any efforts that we might make in behalf of railroads. If we would be influential in our friendship for the railroads, our attitude must not be that of condonation of any wrong, but staunch advocacy of fair play all round. We are manufacturers of railroad materials, not vendors of taffy.

There is serious work to be done. We want orders. We want to see the fires lighted in our furnaces, profits flowing into our coffers, workingmen made glad by the joyous sound of the shop whistles calling them from idleness to work. Not one of these hopes can be realized until railroads are relieved of the incubus of hostile agitation that now halts their successful operation.

It is admitted that some reforms are necessary and desirable in the conduct of railroads, to the end that discontent may be quieted. It is conceded that as public servants, exercising the great powers conferred upon them by the people, intended for the public good, and possessed of franchises of untold value, granted them by legislation, railroads should be subjected to proper regulation and supervision by the people through constituted authority. But there is a vast difference between healthful, sane regulation and vicious strangulation. Not every carping critic is a Solomon; nor is every lawmaker a statesman. Because a law is aimed at a railroad does not necessarily make it right or expedient; it may be wrong and work injustice. Hot-headed legislators enact hot-headed legislation. Statutes conceived in wrath have their fruition in paralyzed commerce. As abaters of the smoke nuisance they have our inventors in that line lashed to the mast.

* * * * * * * * * *

The thoroughly trained, capable and honest officials, whose energies and brains are concentrated upon the problem of conducting the business of railroads profitably to their owners and satisfactorily to their patrons, should be upheld and their work appreciated. They are, in fact, the overwhelming majority.

Those railroad officials who vex the public by temperamental failings, who are brusque and inconsiderate in their intercourse with the public, must be brought to realize that they are in fact public servants and not monarchs.

Those who may be guilty of wicked practices, in the administration of railroad properties, should be scourged with the lash of universal scorn and driven from the railroad field.

Those who decry railroads with malicious intent; who would cripple them to gratify personal spleen, or for personal aggrandizement, must be exposed and their power for evil destroyed.

Those who criticize railroad methods intelligently; who have just cause for complaint in their dealings with railroads, must be accorded respectful audience and be listened to with ears anxious for the truth.

Those who depend upon railroads for subsistence, directly or indirectly, must be loyal to their means of support, and quick to resent interference therewith by crafty or turbulent trouble makers.

Railroads must be operated with a fair margin of profit, else they cannot maintain efficiency in equipment, adequately meet increasing demands for terminal facilities and other betterments, nor can they pay good wages to their operatives. In other business enterprises, it is a maxim that prices include a profit. If there are no profits, there is bankruptcy. There is no reason why transportation rates should not be adjusted upon the same basis.

* * * * * * * * * *

All these things can be accomplished. They must be accomplished. Who are better equipped than bodies of men such as are here assembled, to aid in their accomplishment?

CAR SHORTAGE ON C. P. R.—In a special report by the president of the Canadian Pacific, he said that during the last six years the company had spent \$37,000,000 for locomotives and cars, and yet during the next six weeks there would hardly be enough cars to handle the business offered.

(Established 1832).

AMERICAN ENGINEER AND RAILROAD JOURNAL.

PUBLISHED MONTHLY

BY

R. M. VAN ARSDALE

140 NASSAU STREET, NEW YORK

J. S. BONSALL,

Business Manager.

R. V. WRIGHT, E. A. AVERILL, Editors.

NOVEMBER, 1908

Subscriptions.—*$2.00 a year for the United States and Canada; $2.50 a year to Foreign Countries embraced in the Universal Postal Union. Remit by Express Money Order, Draft or Post Office Order. Subscription for this paper will be received and copies kept for sale by the*

Post Office News Co., 217 Dearborn St., Chicago, Ill.
Damrell & Upham, 283 Washington St., Boston, Mass.
Philip Roeder, 307 North Fourth St., St. Louis, Mo.
R. S. Davis & Co., 346 Fifth Ave., Pittsburg, Pa.
Century News Co., 6 Third St., S. Minneapolis, Minn.
W. Dawson & Sons, Ltd., Cannon St., Bream's Buildings, London, E. C., England.

Advertisements.—*Nothing will be inserted in this journal for pay,* EXCEPT IN THE ADVERTISING PAGES. *The reading pages will contain only such matter as we consider of interest to our readers.*

Contributions.—*Articles relating to Motive Power Department problems, including the design, construction, maintenance and operation of rolling stock, also of shops and roundhouses and their equipment are desired. Also early notices of official changes, and additions of new equipment for the road or the shop, by purchase or construction.*

CONTENTS

We have been surprised and delighted at the interest which is being manifested in the Railroad Club Department. Mr. Turner has presented a very interesting question for discussion in this issue and we hope that our readers will not be slow in either criticising or commenting upon this or in submitting other questions, the discussion of which they believe will be profitable for promoting the interests of the railroad clubs."

There has been a rumor, which has been accepted as true by one of our English contemporaries and has also been published as a fact by some American technical papers, to the effect that Mallet articulated compound locomotives are to be used for passenger service in this country. While such a design has been suggested, so far as we have been able to determine, there are none being constructed, nor does it seem probable that there will be any Mallet type of locomotives built for high speed service for some time to come.

REDUCING GRATE AREA.

The application of a narrow fire box with but 33 sq. ft. of grate area to a large Pacific type locomotive having 3,927 sq. ft. of heating surface and weighing 243,200 lbs. total is a decided departure from the usual present day practice in locomotive design. This refers to the Chicago & Alton R. R. locomotive illustrated on page 399 of the October issue of this journal. This road, in common with most others, was greatly troubled with leaky flues and fire boxes, particularly in bad water districts, upon the general introduction of the wide fire box boiler five or six years ago. Careful study of the problem led first to experiments with wider bridges and hence fewer flues and less heating surface, which proved successful in reducing flue leakage troubles very materially with no noticeable reduction in boiler capacity. It was next decided that the short life of the fire box sheets and the excessive leakage was largely caused by the straight side sheets. Experiments with one of the same class of locomotives, fitted with a narrow fire box, having curved side sheets and wide water legs, proved the accuracy of the conclusion. In two years' service it was found that the cost of maintaining the wide and narrow fire box boilers on otherwise identical locomotives varied in the ratio of 4 to 1. As a result the next order of twenty-five Atlantic type locomotives were fitted with narrow fire boxes and after two years' experience with them the same design is retained on five Pacific type locomotives.

Of course, the reduction of grate area has increased the rate of combustion per square foot and it has probably also somewhat increased the coal consumption per hour. The recent experiments on the testing plant at Altoona indicate that if the fire box volume is not reduced the increase in the rate of combustion per square foot of grate area within reasonable limits does not affect the efficiency of the absorption of the heat, although it does affect the efficiency of the combustion. The latter feature, however, depends so largely upon the quality of coal used that no rate can be given which would have general application. As regards the fire box volume in the present case the narrow grate has reduced it much less than might be expected.

GONDOLA COAL CAR DESIGN.

A 100,000 lb. steel gondola car for the Virginian Railway, which is illustrated on page 413 of this issue, was designed for conditions of service which will be particularly severe. This new railway is to be almost exclusively a coal handling road and no expense has been spared, in building and equipping it, which would reduce the cost of handling or transporting this product. The roadway has been constructed to permit the economical handling of trains weighing 6,000 tons behind the locomotive; the cars are of as large capacity as previous experience has shown to be

desirable under present conditions; the distribution of cars in the yard will be by the most rapid and hence the most severe method and the loading and unloading will be performed by the most modern methods for rapid and cheap handling. In other words the proposition put up to the car designer in this case is probably more difficult than he has been called upon to meet before and it represents the very latest present day requirements for a coal carrying car. For this reason the design is interesting, more especially as the conditions which it will meet will without doubt soon become general for cars of this class and it will be necessary for all such cars to stand them.

The most prominent features in the design, as a whole, are the unusually strong, rigid sides and ends and the very heavy center sills. The finally accepted design, as shown on page 413, is considerably lighter than was that which was published some time ago, but this decrease in weight has been obtained with little or no sacrifice of strength and possibly with an increase of flexibility. The center sills are nearly 34 sq. in. sectional area, a figure which equals that used on many steel passenger cars of half again the length, and should certainly prove to be amply strong for even the most severe hump yard mis-handling. The ends have been arranged to stand the same service and the sides are designed to withstand treatment in a Hewlitt car un-loading machine where they will have to support at eight points, four on each side, not only the weight of the car itself but also a pressure equal to the weight of the lading which the reacting of the springs will place upon it when the load is discharged.

VALUE OF GOOD READING.

It is with considerable pleasure that we reproduce in this issue a portion of an address on "Self-Improvement" made before the Richmond Railroad Club by W. H. White, president of the Richmond, Fredericksburg & Potomac Railroad. His suggestions as to the broadening and uplifting effect of good reading have been forcibly brought home to us during the past week by two acquaintances who dropped in at different times for a little chat with the editors. Both of these men were thrown on their own resources at the age of thirteen; both hold splendid positions in the motive power department and their names are familiar to the readers of this journal; both are hard workers and have made splendid records, and yet they have found time to surround themselves with good books and to devote more or less time to studying them; both are regarded as men of culture in the communities in which they live, and both belong to clubs which are noted because they are frequented and supported by men of culture. One of the men especially spoke enthusiastically of the broadening and uplifting effect which the reading and studying of good books had on him.

Are we so wrapped up in our work that we neglect to avail ourselves of intimacy with the master minds in literature? Is there not such a thing as giving too much of our time to the occupation by which we earn our daily bread, so that our mental growth is unsymmetrical and we run the danger of becoming narrow-minded? Will not a course in general reading broaden us out so as to make us of greater value to our employers and increase our earning power and our influence in the community? It is not so much the amount which we read as the quality, and the thought which we give it.

ORGANIZATION.

Last month we commented on the most efficient form of organization. While the railroads and industrial establishments remained comparatively small the need of this was not so strongly felt, since the head of the concern was in most cases not far removed from the men in the ranks and could easily familiarize himself with the workings of the entire organization. But conditions have changed. These concerns are now so large that there is a great gap between even the heads of the departments and the men in the ranks. Railroads, for instance, have grown so great that there are many workmen who have never seen the man at the head of the department in which they work. Under these conditions it is essential that the machinery of organization be so carefully designed that all unnecessary friction and waste will be eliminated and that in effect, if not in fact, the officials will be almost as closely in touch with the workmen as under the old conditions.

But right here we are confronted with a problem which is even more important than that of evolving a proper form of organization. It is to build up a spirit of team work and co-operation which will permeate the entire organization and will force down out of sight department lines, the men working enthusiastically for the good of the road as a whole. It means that there will be a spirit of enthusiasm throughout the organization. It is impossible to estimate what this would mean in dollars and cents, but surely its value cannot be overlooked by even the most selfish and self-centered official. What a pleasant shock it would be for the railroad directors and stockholders if, say for three months, all of the unnecessary friction and useless bickering between their servants (on some roads) could be eliminated and each employee could consider himself as a heavy stockholder. If only a little bit more of the Golden Rule could be injected into the average railroad organization the result would be surprising.

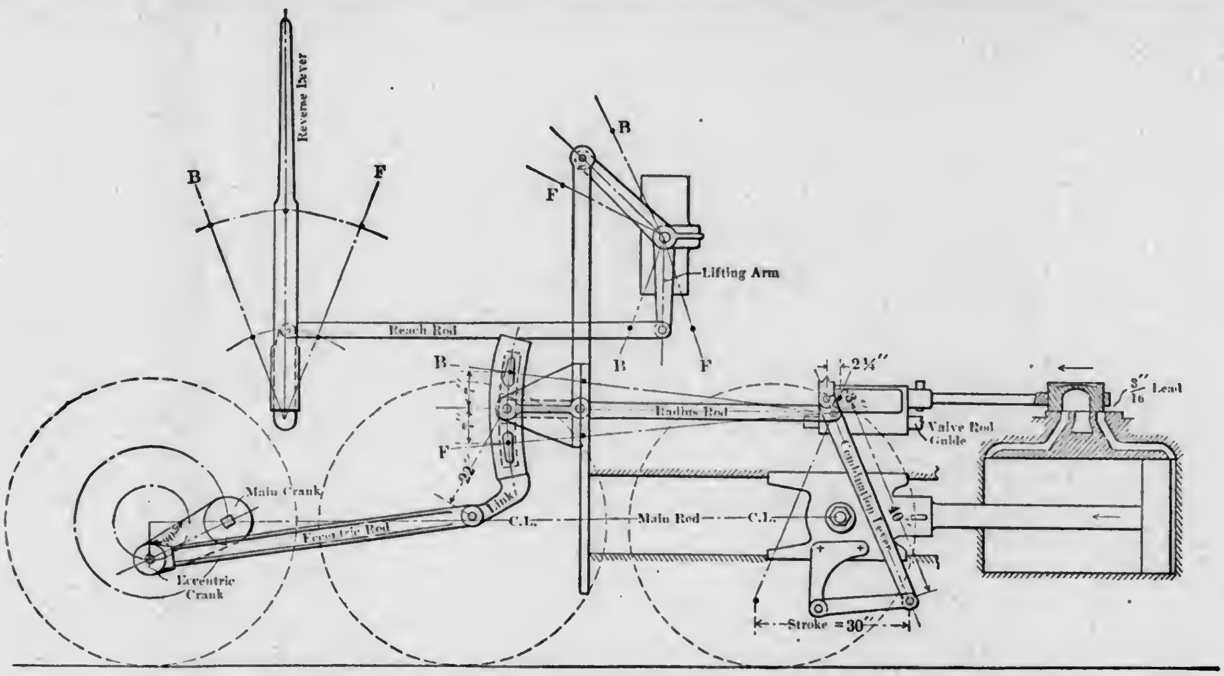
Fortunately there are mechanical departments on some roads in which there is more or less of this spirit of team work and co-operation. It is extremely rare, however, when one can find the happy combination of enthusiasm, team work and co-operation in connection with the most efficient form of organization. There is at least one road on which these conditions exist, and we hope in the next issue to place before our readers the details of what we believe to be the finest motive power department organization on this continent, if not in the world.

LOCOMOTIVE CHARACTERISTICS.

The diagrams presented by Lawford H. Fry on page 416 of this issue are arranged to give the information concerning the operation of single expansion locomotives which was given in a similar set of curves by the same author for balanced compound locomotives about a year ago (Oct. 1907). These curves permit the convenient and rapid determination of almost any desired information in connection with the operation of the locomotive under any assumed conditions. While the examples given by the author as an illustration, start with the assumption that the locomotive is capable of maintaining 60 per cent. of its maximum tractive effort at 150 revolutions per minute, under which conditions the water consumption, boiler efficiency, etc. are obtained, it is, of course, equally accurate when reversed, that is, by assuming or knowing a certain boiler capacity or efficiency is possible, to determine at what speed a certain proportion of the maximum tractive effort can be maintained and what cut-off will be required to do it. Such information would be valuable in connection with the preliminary investigation of the advisability of applying a standard boiler, the characteristics of which had been determined on one type of locomotive, to another type or size of engine. Application could also be made for an investigation of the alterations necessary to remedy an unsatisfactory design, etc.

The curves are also capable of giving considerably more information than they are designed to give by direct reading. A couple of examples of this are given by the author in connection with a constant horse power curve and the water consumed per horse power hour for any combination of cut-off and speed.

It will be noticed in the fourth section of this diagram that the author has differentiated between two classes of coal. This is a very important feature, which should be given very careful consideration. When using the curves for any known conditions to obtain accurate results it might be necessary to use other curves the relative location of which would depend on the chemical analysis and quality of the coal to be used. The reference given in the article will show the quality of the coal which determined the location of the curves in the diagrams.



ARRANGEMENT OF WALSCHAERT VALVE GEAR AS EXAMPLE FOR SETTING.

SETTING WALSCHAERT VALVE GEAR.

By R. S. Mounce.

The Walschaert valve gear is comparatively new in this country, and with this fact in view the following set of rules applied to a specific case, but which can of course be made general, may be of interest to many who are in charge of applying new gear, or in re-applying the gears during general repairs to an engine already so equipped.

Since in designing Walschaert gear, the foot of the link is backset in such a way as to equalize the valve travel with respect to top and bottom quarters of crank pin, if the engine is set square in full gear, it will be very close to square in running positions or positions of shorter cut-off. Because of this it is very good practice to adjust the various parts for full travel, then,

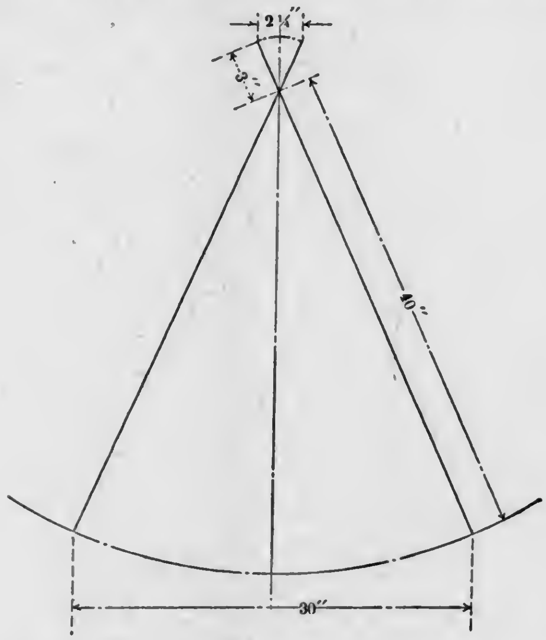


FIG. 1.

if desired, it is a very simple matter to run the engine over, with reverse lever in the running position.

In setting the valves on an engine with this gear, the full travel must first be made equal in both motions to a certain standard distance. There are several errors in the parts which may cause this to vary. The most convenient method for adjusting the travel is to shorten or lengthen the reach rods such an amount (which can be readily estimated by trial, or from the geometry of the mechanism), as to make backward and forward travel equal on both sides of the engine. In case, after the travel is equalized, the distance is too short, the stops will have to be moved on the quadrant, the front one ahead and the back one back, a proper amount to give the correct travel. After these adjustments have been made, the distance of the link block from the center of the link will be the same for both motions.

Since in this motion the return crank is approximately 90 degrees from the crank pin, the lead at dead center must be given by the combination lever attached to the cross head. The throw given by this lever should next be adjusted. The eccentric rods are removed and the links set exactly plumb or central. Now by rotating the main wheel, the amount of travel of the valve due to combination lever can be adjusted. In the assumed case the steam lap of valve =15/16", and the lead is to be = 3/16". This large amount is taken because, on the Walschaert gear, the lead cannot be increased when engine is running in the so-called "cut off" position, so to give a fair average to suit running and starting travel of valves, 3/16" is taken for the lead. Now it can

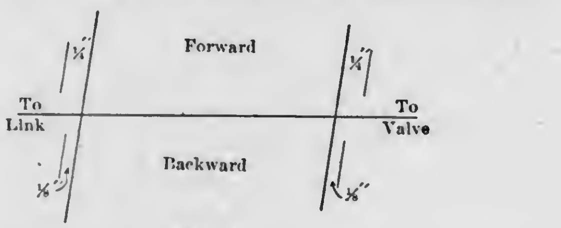


FIG. 2.

readily be seen that the stroke of valve due to the combination lever must equal 2 (15/16" + 3/16) = 2¼".

Assume that the stroke given in this particular case is 2⅛". It will be necessary to adjust the combination lever to make this stroke 2¼".

Now, referring to Fig. 1, from the principle of similar triangles 3:40 = 2¼:30 where 3" and 40" are lengths of combination lever arms and 2¼" and 30" are the stroke of valve and piston. Now according to this ratio, using 2⅛" instead of 2¼" the length of combination lever long arm comes out as 42.35" long, which is shown to be true by measurement. Now if the arm is adjusted from its incorrect length to 40", the travel will be such that when finally set the valves will have 3/16" lead.

The next step is to reapply the eccentric rods and again run

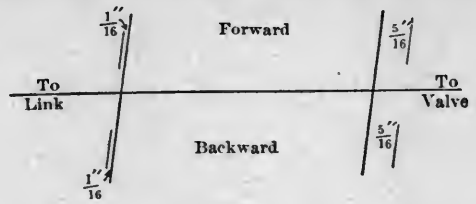


FIG. 3.

the engine over, catching the dead centers and making the corresponding tram marks on valve rod. Assume that the marks on the right side are as shown in Fig. 2. The forward motion has 1/16" too much lead, and the backward 1/16" too little. Since forward motion is direct and backward motion is indirect, the angle of advance of eccentric crank must be decreased, and this will also increase the angle for the backward motion. The lead must therefore be adjusted 1/16" (see large drawing for reason of using fraction 22/7), and to do this the eccentric crank must be moved toward the crank pin 22/7 × 1/16", since the link

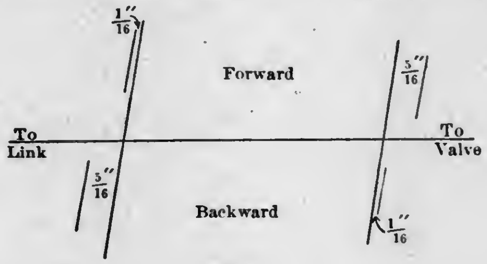


FIG. 4.

block radius in full travel = 7" and radius of eccentric rod pin hole in link is equal to 22". This change will make the lead correct and equal in both forward and backward motion.

The final step in the adjustment, namely, the adjusting of the eccentric and radius rods, is next. There are three possible cases that may came up, and they will be treated separately. A.—Eccentric rod correct and radius rod "out." Assume that on running the valves over, the marks on right are as shown in Fig. 3. This shows that to give same port opening on each end, that valve must be thrown ahead just ⅛". If the radius rod is

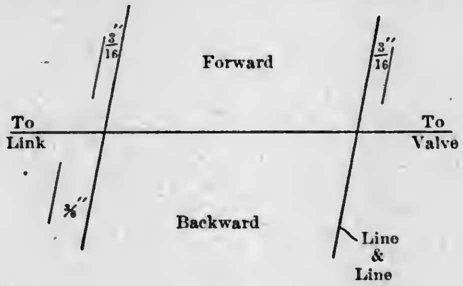


FIG. 5.

lengthened ⅛" the proper adjustment will be made. B.—Eccentric rod "out" and radius rod correct. Assume the marks on right side as shown in Fig. 4. Since forward motion is *direct*, the valve must be thrown ahead ⅛" to make it square. Now if eccentric rod is lengthened ⅛" × 22/7 the forward motion will be correct. The valve of the backward motion must be drawn back to make it square. Since the back motion is *indirect* the valve *will* be drawn back, if eccentric rod is thrown ahead or lengthened 22/7 × ⅛". So lengthening the eccentric rod 22/7 × ⅛" will make the valve correct in position. C.—This case is

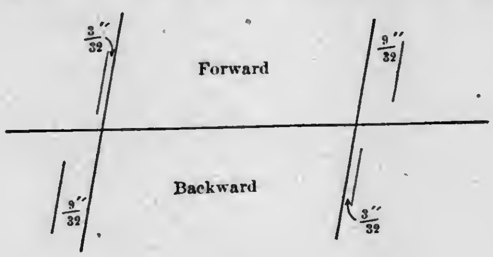


FIG. 6.

when both eccentric and radius rods are "out." Assume that the following marks are obtained when valve is run over on, say, the right side. First (Fig. 5) radius rod will have to be adjusted so as to give marks as in Fig. 6 (shorten radius rod 3/32"). Then using case in Fig. 6 eccentric rod will have to be lengthened 3/32" × 22/7. These alterations will make the valve square.

The above gives a sample case of alterations necessary for adjusting the valve motion of a Walschaert engine, and any case whatever can be adjusted by following a similar course of reasoning.

NEW TERMINAL STATION IN CHICAGO.

The New Chicago terminal station of the Chicago & Northwestern Ry. will occupy about four city blocks and will have its main front on Madison street, between Canal and Clinton streets. The cost of the building alone will be about $4,000,000, while the approaches (with elevated tracks) will cost about $8,000,000. The expenses for land and right-of-way will bring the total cost to about $20,000,000. The building will be of gray granite. The design is of the classic type, with a colonnade 120 ft. high forming the main entrance. The six main entrance stairways will aggregate a total width of 100 ft. There will be three main floors. At the street level, the main entrance will open into a concourse 100 × 250 ft., convenient to the ticket offices, baggage rooms, and special accommodations for immigrants. There will be a separate concourse and other facilities for the suburban traffic. On the second floor, level with the station platforms, will be the waiting rooms, the main room being 100 x 200 ft., and 80 ft. high, with a vaulted ceiling. The third floor will have ladies' rooms, barber shop, and other accommodations.

The present terminal station at Wells and Kinzie streets was built in 1882. An annex for suburban traffic was built a few years ago and additional tracks have been laid from time to time. The passenger accommodations and train facilities are, however, very inadequate for the present traffic. All traffic is throttled by having to cross a double-track swing bridge just outside the station, but this is now being replaced by a four-track Scherzer rolling-lift bascule bridge. There are now over 300 trains entering and leaving the station daily, and there is a very heavy suburban traffic.

The site is now being cleared, ready for sinking the foundation caissons, which will go down about 106 ft. It is expected to have the station completed by January, 1910. The architects are Frost & Granger, of Chicago.

The Herring-Bone Arrangement for Erecting Shops.—It was my privilege to work out and see the completion of the only large shop in the States employing the "herring-bone" arrangement of erecting shop pits. This is a modification between the transverse and longitudinal plans. With such a plan the cranes are in constant use. When not transferring they are used in erection, and the proportion of time expended in the former service is relatively small even with fifty engines on the floor. Engines do not have to pass over each other, hence an economy in the height of the structure and of the lift. Cross-communication throughout the shop is uninterrupted, not as in the ordinary longitudinal plan. This shop has now been in operation four years, and the plan has the hearty approval of those best acquainted with its operation.—*C. A. Seley, Canadian Railway Club.*

Meeting of the A. S. M. E.—The November meeting of the American Society of Mechanical Engineers will be held in the Engineering Societies Building, 29 W. 39th street, New York, on Tuesday evening, November 10. Mr. Franklin Phillips will give an address on "The High Powered Rifle and Its Ammunition," to be illustrated by lantern slides.

A Suction Gas-Engine Outfit is being tried out on the old English warship "Rattler," with a view of determining the practicability of this type of power for ship propulsion.

WITH THE RAILROAD CLUBS.

We should like very much to have an expression of opinion from our readers concerning Mr. Turner's "hobby," as mentioned in his letter on the next page, i. e., that the railroad clubs should appoint a joint committee on subjects and that each club should discuss the same subject during the same month.

Canadian Railway Club.—Next meeting, Tuesday, November 3, at the Windsor Hotel, Montreal, Can. Walter V. Turner, mechanical engineer of the Westinghouse Air Brake Company, will present a paper on "Brakes for Freight Cars from an Economic and Operative Point of View." It will include a review of the conditions affecting this phase of the brake problem and will be illustrated with lantern slides.

Mr. Thornton's paper on the "Chemistry of Rubber," presented at the October meeting, was largely devoted to the methods of procuring the crude rubber.

Bruce Robb, son of W. D. Robb, superintendent of motive power of the Grand Trunk Railway, and a former president of the club, was announced as the successful competitor for the first Canadian Railway Club scholarship at McGill University.

Secretary, James Powell, P. O. Box 7, St. Lambert, near Montreal, Can.

Central Railway Club (Buffalo, N. Y.).—Next meeting, Friday, November 13. At the time of going to press the subject to be discussed at this meeting had not been decided upon.

Secretary, Harry D. Vought, 95 Liberty street, New York City.

New England Railroad Club (Boston).—Next meeting, Tuesday, November 10, at the Copley Square Hotel. A paper on "Railroad Stations" will be presented by Henry B. Fletcher, architect of the Boston & Maine Railroad.

Secretary, G. H. Frazier, 10 Oliver street, Boston

New York Railroad Club.—Next meeting, Friday, November 20, at the Engineering Societies' Building, 29 West 39th street, New York City. W. J. Harahan, assistant to the president of the Erie Railroad, will speak on "A Search for Those Elements, the Proper Combination of Which Constitute the Successful Railway Official." This will also be the annual meeting of the club.

The proceedings of the September meeting, containing Mr. Emerson's paper on "Better Service at Reduced Cost" and the discussion thereon, have been received. An interesting addition to the paper, not printed in the advance copies, is a bibliography of leading articles relating to improved efficiency and economy of operations, as applied to locomotive tool equipments; railway shop tools, machinery and methods; alloy tool steel for high-speed metal cutting; shop methods and organization; labor efficiency and material economy.

At the September meeting the list of subjects to be presented up to and including the May, 1909, meeting was read. In commenting on this the president, Mr. Vreeland, said:

"It was only a few years ago when it was very hard to give out the subjects to be presented a week in advance of the meetings. The appreciation of members is evidenced by the fact that railroad men and prominent scientific men interested in these subjects now offer papers or desire to present these subjects before the club so that we can announce for the whole season the subjects which are to be discussed at the regular meetings."

The paper at the October meeting was on "Heat Accumulators in Steam Engineering" by L. Battu. It applied particularly to the Rattau steam re-generator which has been the source of very great saving at points where reciprocating steam engines are in use intermittently, such as, for instance, in rolling mills, hoisting engines at mines, etc. By means of this re-generator the steam which is normally allowed to escape to the atmosphere is used to supply a low pressure turbine, which exhausts in a vacuum and drives a generator. The paper was discussed, among others, by L. R. Pomeroy, who related how heat storage had been carefully considered in connection with the problem of power plant design for the Sarnia tunnel of the Michigan Central Railway in connection with its electrification. Mr. Pomeroy presented some very interesting data in connection with heat storage. Later George A. Damon of the Arnold Company explained how the principle had been applied in practice at the above mentioned power plant. The application consisted of installing specially designed boilers, with large water and steam space, which are filled to the top of the glass before the peak of the load comes on the plant and the water level is allowed to fall during the time of overload, being filled up later as the plant runs below its capacity. The overload capacity of the generators takes care of the electrical end and in this way sufficient steam supply is obtained with boilers rated for the average daily load.

The following officers have been nominated and the ticket will be submitted to letter ballot; the result of the vote will be announced at the November meeting. President, J. F. Deems, general superintendent motive power, rolling stock and machinery, New York Central Lines; first vice-president, W. G. Besler, vice-president and general manager, Central R. R. of New Jersey; second vice-president, H. S. Hayward, superintendent of motive power, Pennsylvania R. R.; third vice-president, Frank Hedley, vice-president and general manager, Interborough Rapid Transit Co.; treasurer, R. M. Dixon, president, Safety Car Heating & Lighting Co.; executive members (three years), E. T. Campbell, purchasing agent, Erie R. R.; (one year) G. H. Campbell, general superintendent, Baltimore & Ohio; member of finance committee for three years, B. A. Hegeman, Jr., president, United States Metal & Mfg. Co.

Secretary, Harry D. Vought, 95 Liberty street, New York City.

Northern Railway Club (Duluth, Minn.).—Next meeting, Tuesday, November 24. N. P. White, roundhouse foreman of the Northern Pacific Railway at Duluth, will read a paper on "Engine Repairs in the Roundhouse from the Standpoint of a Machinist." The same subject, from the standpoint of a boilermaker, will be treated by Claude Richards.

At the July meeting a code of discipline for operating employees was submitted by a special committee. It was carefully discussed and at the September meeting it was adopted as recommended practice.

At the September meeting the discussion of a paper on "Brick Arches for Locomotives," presented at the June meeting by Charles Cotter, was completed. J. W. Kreitter, vice-president of the club, gave a brief report of the practice on each of nine of the northwestern roads. In summing up this investigation and the discussion which had taken place at the two meetings of the club he spoke as follows:

"In good water localities, the brick arch is an economy. In bad water localities, it is not."

"The arch flue should not be used, for while it might be used safely, with proper care, it has been shown that serious injuries and fatalities have occurred from its use. Angle irons or studs, fastened to the side sheets, should take the place of the flues.

"The use of the hollowed brick seems to be an improvement over the common brick, in addition acting as a smoke and spark consumer.

"The best results seem obtainable from the use of the brick arch in small engines.

"Mechanical members of this club should recommend to their officials an immediate experiment with several engines, with and without arches, with small and large engines. Also with com-

mon and hollowed brick, so that in the near future we may take this question up with additional practical information. With a road doing a large business, the time an engine spends in the roundhouse is of the utmost importance, so the experiments should bring out the time consumed preparing an engine, with and without brick, for a washout; time getting at flue repairs, with and without brick; time making the repairs, labor taking out and replacing the brick, cost of brick, fuel saving, etc."

At the same meeting a paper on "Locomotive Boiler Washing" was presented by C. W. Seddon, superintendent of motive power and cars of the Duluth, Missabe and Northern Railway. He directed attention to the importance of washing out locomotive boilers regularly and the necessity for both the mechanical and operating departments to co-operate in insisting that this be done. It is a serious mistake to intrust the work of washing out to "green" or unskilled and cheaply paid labor. He contrasted the cold and hot water methods of washing out and described the apparatus for washing out with hot water which is in use at the Proctor roundhouse of the road with which he is connected. In speaking of the results due to this installation he said: "We have found from the use of hot water a marked improvement in the cost of the maintenance of locomotives over the old system of using cold water; we have had less trouble from leaky tubes, cracked side sheets and broken staybolts and are firmly convinced that the installation of the hot water system is money well spent and will more than pay for itself in a year." Boiler washout report forms which must be filled in and sent to the office of the superintendent of motive power and the roundhouse foreman's record sheets were reproduced in the paper.

At the October meeting a paper on "Concrete and Steel Ore Docks vs. Wooden Docks" was presented by W. A. Clark, chief engineer of the Duluth & Iron Range Railroad.

Secretary, C. L. Kennedy, 401 West Superior street, Duluth, Minn.

Railway Club of Pittsburgh.—The subject for the next meeting, which will be held on November 27, had not yet been decided upon when our forms were closed.

Secretary, J. D. Conway, P. & L. E. R. R., Pittsburgh, Pa.

Richmond Railway Club.—Next meeting, Monday, November 9. An election of officers will be held and this meeting will also be a "Ladies' Night," at which some appropriate form of entertainment will be provided.

W. H. White, president of the Richmond, Fredericksburg & Potomac Railroad, made a most interesting address on "Self-Improvement" at the September meeting. A portion of this address, and also an editorial comment concerning it, will be found on other pages of this issue.

St. Louis Railway Club.—The next meeting will be held Friday, November 13, at which time the president of the club, John J. Baulch, superintendent of transportation of the Manufacturers' Railway, St. Louis, will read a paper.

The proceedings of the September meeting, containing the paper on "Relation of American Mining Schools to the Mineral Industry," by L. E. Young, director of the Missouri School of Mines, have been received. Mr. Young directed attention to the importance of mining in the United States and the fact that the American mining engineer stands at the head in his profession. He spoke of the broadness of the mining engineering courses and called attention to special features in mining education. The work of the mining schools in this country, especially of the Missouri School of Mines, was briefly considered. The remainder, and largest portion of the paper, was devoted to a consideration of the mining field, the place of the mining graduate in it, and some of the future problems which must be solved.

Secretary, W. B. Frauenthal, Union Station, St. Louis, Mo.

Western Railway Club.—Next meeting, Tuesday, November 17. Prof. C. H. Benjamin of Purdue University will present a paper on "The Impact of Fly Wheels and Drivers and Methods for Measuring."

At the October meeting E. W. McKenna, second vice-president of the Chicago, Milwaukee & St. Paul Railway, spoke on "A Constituency Without Representation." The railroad officials and employees of Chicago have effected an organization looking toward the better protection of the railroads, and necessarily of the railroad employees and those depending upon railroads for a living, from demagogical legislation, both national and state. A brief account of the formation of this organization will be found on another page of this issue. A similar organization of railway supply firms was recently effected in New York. George Post was made president. An extract of an address made by him will also be found on another page of this issue. The object of Mr. McKenna's talk was to further advance this movement. The constituency referred to includes those persons dependent upon the railroads and allied interests, which, roughly, constitutes about one-fifth of the population of this country.

The railroad library of the late Everitte St. John, formerly general manager of the Chicago, Rock Island & Pacific, and later vice-president and general manager of the Seaboard Air Line, has been presented to the club. It consists of 170 volumes.

At the September meeting the membership of the club was reported to be 1,508.

Secretary, J. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

Some Good Suggestions Concerning Railroad Clubs.

To the Editor:

While unquestionably the railroad clubs of the country are doing lots of valuable work, their usefulness might be increased to a great degree. The first and most important thing is to work up a greater interest. There are hundreds of men attending club meetings year in and year out who never say a word or do anything to encourage a club, except by their presence; in almost every instance they are capable of taking an active part in the meetings and in so doing would make them much more interesting and give others the benefit of their knowledge, and incidentally profit themselves.

Railroad club officers have much difficulty in securing good papers and a greater difficulty in getting them properly discussed after they have been secured. There is nothing that broadens men more than attending meetings of this sort and taking an active part in the discussion. I have always believed that the railroad clubs are capable of doing more work and better work for the railroads than either the Master Mechanics' or Master Car Builders' Associations. It is true that the M. C. B. Association is in position to enact certain laws, which could not be done by the railroad clubs; but, when it comes to the matter of improvement of railroad equipment, club work makes it easy for the members to put themselves in position to carry out their tests and experiments and accomplish greater results than either of the Associations, provided, of course, that the members take an active interest in the work.

"I have had a hobby for some years, but so far have been unsuccessful in getting anyone to ride it but myself, to the effect that the railroad clubs of the United States should appoint a joint committee on subjects, and that each club should discuss the same subject the same month that the other clubs are handling it; if you can get five or six of the best clubs discussing the same subject at the same time, with a membership of anywhere from four to six thousand, and the members as a class taking an active interest, it is safe to assume that there will be very little left of the subject which would not be thoroughly threshed out by the time the reports were all in, and I believe that were five or six of the best clubs to take up any particular subject, that the findings of the whole would be very valuable to any railroad interested in that particular subject. The American Engineer can accomplish great results if it is able through its efforts to build up a greater interest in club work and get more of the members to take an active part in it.

L. H. Turner.

P. & L. E. R. R., Pittsburgh, Pa.

SELF-IMPROVEMENT.

The following is taken from an address before the Richmond Railroad Club by W. H. White, president of the Richmond, Fredericksburg & Potomac Railroad:

The theme is trite, but most significant—in my judgment, the most important in American life to-day. We are living under an order social and political, which puts no barrier in the pathway of any man who aspires to the high and influential places of his country; unlike some of the older governments, where custom is often tyrannous and church and state are only open to a favored few, favored rather by accident of birth than by individual qualities and attainments. We, every one of us, have before us from the cradle to the grave an open road to every distinction, private and public. In a word, there can be no contest with us for individual privilege and ample opportunity. A man is a man among men or a drone among drones, as he wills and determines. Are any of you railroad men, firemen? Then remember that one of the most efficient railroad presidents of this country was a fireman. Are any telegraph operators? Then know that quite a score of the present prominent railroad officials were telegraph operators. Are any clerks? Remember that many of the controlling men in public life to-day started as clerks, and one is a conspicuous cabinet officer at Washington, in control of the vast financial life of the government. So that it is now, gentlemen, an axiom that it is merit that makes the man, not social or political favoritism. It is individual purpose, energy and ambition which make the successful men of America. There is no need, therefore, to spend any energy in removing artificial impediments from any life-career you may select.

The one and only thing is for the man to prepare himself for his career; to be ready to embrace the fitting occasion when it comes. External and scholastic training may be of value in teaching one how to think, but it depends on the man himself whether and how he will think. This is what I understand to be self-improvement. Think for yourself, developing your brain power as you do that of your legs and arms, for reflect that the muscles of the brain wither or grow just as those of all other parts of the body. Tie your arm up in a sling and let it be idle for a month—it will in that short while grow flabby and frail. Let your brain be idle for the same time, and, like the arm, it becomes feeble and suggests decay. On the other hand, use it with regularity and a true upbuilding purpose, and, like the athlete training for the physical race, its muscles will grow strong, and what is far more to the purpose, its use and exercise will afford a far greater and more certain delight than that which any purely physical exercise can give. A mental joy is as far above a physical one as mind is above matter—as heaven is above earth.

I fancy no one will combat these views, but many will ask: "How can men improve themselves?" Each one differs so radically from the other. Tastes and temperaments enter so largely into the case. True; but fortunately the great God has given to every mind an appetite for something. He has imparted to the brain the same necessity for action as he has to everything else in nature, animate and inanimate. This appetite is there and must be gratified. The mind cannot stand still. This appetite must be appeased with good or bad food. In my judgment, the one way open to all for self-improvement is reading books that contain the garnered wisdom of the ages. The man who cultivates the reading habit is not going to cultivate vicious and deleterious habits. This opportunity is open to all. Books have come within the reach of the poorest. They are always at hand. Not always such as make you think upward, but of this class the supply is equal to every demand.

Without the slightest fear of successful contradiction I assert that the habit of reading good, thoughtful books is the unfailing road to self-culture and individual uplift and happiness. Again, it is the one habit which never fails to give the highest pleasure, the pleasure that brings lasting and helpful memories, the pleasure you can share with others, whether friends and acquaintances, or the members of your household—your wives and children. It is the one light in life that never fails, that shines in the darkest places, relieves the tedium of the sick room, and makes brighter by the higher conception not only this but the future life.

Take my word for it, gentlemen, that a good book is the best companion which a man can have. It matters not what a man's calling is, there will always be at least one hour of the twenty-four when he can enjoy his book. He can in spirit talk with it, study the motives and purposes of the author, compare the writer's views with his own, dissect it if he pleases, and fancy how he would have treated the same subject. Above all, if the opportunity is at hand talk with a friend of what you have read. As this habit of reading grows on you, it becomes the cherished delight of each day, and you approach your book with the same desire for mental exercise that you do your bed for physical rest.

Of course, much depends upon your selection of a book. But if it is fiction you desire you cannot err in selecting Scott, Thackeray, Washington Irving or Nathaniel Hawthorne. They are easily attainable and in pocket editions. If poetry, then again Scott, for his prose and poetry are perennial. They delight us in youth, middle-age, and even the chimney-corner period of life. Longfellow, Whittier, Edgar Poe, among our own poets, will afford an ample satisfaction to the most exacting. If history, then Green's "Short History of the English People," a book which contains more and better material in briefer compass than any I know. Among our own historians none can read Motley and Prescott without realizing their brilliancy and value. If all forms of literary entertainment are desired in two books, then the Bible and Shakespeare. The man who has these two at his mental call is not only the man whose silent moments are happy, but a man who is a power among men and never lonely with himself. He is a man whose brain daily undergoes conscious expansion; for remember, gentlemen, that the human mind is the part of God's creation which continues to grow after the body stops and grows feeble.

I had the pleasure of intimate acquaintance with a lawyer who knew Shakespeare and the Bible almost by heart. He literally lived in the atmosphere of these two books. His thoughts and feelings were colored by them, and I assure you he was before court and jury lofty, forcible, instructive, and, therefore, formidable.

In conclusion, I ask you to try my suggestion for a month. Get a fine book, devote an hour each day to it, and tell me at the end of that time if you have not been conscious of improving yourself. Yes, and conscious that you are better able to meet your daily duties; better able to understand and withstand some at least of the many efforts of charlatans and demagogues who trade on the supposed ignorance of the unthinking. You and all who study self-culture will gradually uplift the standard of citizenship until it attains a plane which will afford no place for those who are false teachers.

Railroad Fuel Men to Organize.—A circular letter is being issued inviting all purchasing and fuel agents, fuel supervisors, fuel accountants, and chief clerks to heads of departments handling fuel on railroads, to attend a meeting to be held in the Parlors of the Auditorium Annex Hotel, Chicago, on November 20, at 10 A. M., for the purpose of organizing an association. Such an association could properly take up and discuss the best and proper methods of handling, inspecting, weighing, distributing and accounting for fuel and oil. Those wishing to attend this meeting are requested to address Eugene McAuliffe, general fuel agent, Rock Island-Frisco Lines, La Salle Street Station, Chicago, Ill., who is chairman of the organization committee.

B. of L. E. Building.—The Brotherhood of Locomotive Engineers is to have a home of its own. Mr. W. S. Stone, grand chief, has announced that it has been decided to erect a building in Cleveland, Ohio, for a home office, the building, equipment, etc., to cost about a million dollars. It is to be twelve stories high and modernly equipped throughout, besides having a large auditorium with a seating capacity of about 1,600 or 1,800. This organization now has a membership of over 63,000.

COMBINED SIMPLE AND COMPOUND LOCOMOTIVE.

COMPARATIVE TRIALS OF SIMPLE AND COMPOUND LOCOMOTIVES.

GREAT NORTHERN RAILWAY (ENGLAND).

In 1906, Mr. Henry A. Ivatt, locomotive superintendent of the Great Northern Railway of England, carried on a most carefully conducted series of trials, in regular service, of three locomotives which were entirely comparable in every respect, except the arrangement of cylinders and the steam distribution. The results of these trials was reported before the Institution of Mechanical Engineers by Mr. Ivatt and are given later in this account.

SIMPLE ATLANTIC TYPE LOCOMOTIVE.

We have been fortunate in obtaining from Mr. O. V. P. Bulleid, assistant works manager of the locomotive department of the Great Northern Railway at Doncaster, some general drawings and information concerning the design of the locomotives under trial which permits the results of the trials to be much better appraised.

Of the three locomotives tested No. 1300 is four cylinder balanced compound Atlantic type, having a narrow fire box, built by the Vulcan Foundry Co. No. 292 is a four-cylinder combined compound or simple Atlantic type locomotive with a wide fire box, which was designed and built by the Great Northern Railway, as was also No. 294, which is a two-cylinder simple Atlantic type with a wide fire box. All of these engines, as will be seen by reference to the table of dimensions, are practically equal in weight and power and permit a fair comparison to be obtained between simple and compound working.

Locomotive No. 1300 is a compound of the DeGlehn type with cylinders 14 and 23 x 26 in., having piston valves on the high and slide valves on the low pressure cylinders. The high pressure cylinders on the outside of the frames connect with the rear driving wheels and the low pressure, placed just below the smoke box between the frames, connect with the cranked axle of the front pair of drivers. The steam pipe passes down inside of the front end and emerges just underneath the barrel of the boiler and between the frames, being continued by a curved pipe to the high pressure steam chest. The locomotive is fitted with a variable exhaust nozzle and with gridiron type of throttle valve. Each wheel has its own individual spring rigging and the weight is not equalized between the different wheels. In this respect the three locomotives are alike. The fire box gives 31 sq. ft. of grate area, setting between the plate frames and having a very deep throat. The boiler tubes are of the Serve type with 7 ribs. They are 2¾ in. diameter and are set with 1 in. bridges. The tubes occupy 31 per cent. of the barrel at the smoke box end. The general dimensions of the locomotive are given in the accompanying table. From these

DEGLEHN COMPOUND LOCOMOTIVE.

SELF-IMPROVEMENT.

The following is taken from an address before the Richmond Railroad Club by W. H. White, president of the Richmond, Fredericksburg & Potomac Railroad:

The theme is trite, but most significant—in my judgment, the most important in American life to-day. We are living under an order social and political, which puts no barrier in the pathway of any man who aspires to the high and influential places of his country; unlike some of the older governments, where custom is often tyrannous and church and state are only open to a favored few, favored rather by accident of birth than by individual qualities and attainments. We, every one of us, have before us from the cradle to the grave an open road to every distinction, private and public. In a word, there can be no contest with us for individual privilege and ample opportunity. A man is a man among men or a drone among drones, as he wills and determines. Are any of you railroad men, firemen? Then remember that one of the most efficient railroad presidents of this country was a fireman. Are any telegraph operators? Then know that quite a score of the present prominent railroad officials were telegraph operators. Are any clerks? Remember that many of the controlling men in public life to-day started as clerks, and one is a conspicuous cabinet officer at Washington, in control of the vast financial life of the government. So that it is now, gentlemen, an axiom that it is merit that makes the man, not social or political favoritism. It is individual purpose, energy and ambition which make the successful men of America. There is no need, therefore, to spend any energy in removing artificial impediments from any life-career you may select.

The one and only thing is for the man to prepare himself for his career: to be ready to embrace the fitting occasion when it comes. External and scholastic training may be of value in teaching one how to think, but it depends on the man himself whether and how he will think. This is what I understand to be self-improvement. Think for yourself, developing your brain power as you do that of your legs and arms, for reflect that the muscles of the brain wither or grow just as those of all other parts of the body. Tie your arm up in a sling and let it be idle for a month—it will in that short while grow flabby and frail. Let your brain be idle for the same time, and, like the arm, it becomes feeble and suggests decay. On the other hand, use it with regularity and a true upbuilding purpose, and, like the athlete training for the physical race, its muscles will grow strong, and what is far more to the purpose, its use and exercise will afford a far greater and more certain delight than that which any purely physical exercise can give. A mental joy is as far above a physical one as mind is above matter—as heaven is above earth.

I fancy no one will combat these views, but many will ask: "How can men improve themselves?" Each one differs so radically from the other. Tastes and temperaments enter so largely into the case. True; but fortunately the great God has given to every mind an appetite for something. He has imparted to the brain the same necessity for action as he has to everything else in nature, animate and inanimate. This appetite is there and must be gratified. The mind cannot stand still. This appetite must be appeased with good or bad food. In my judgment, the one way open to all for self-improvement is reading books that contain the garnered wisdom of the ages. The man who cultivates the reading habit is not going to cultivate vicious and deleterious habits. This opportunity is open to all. Books have come within the reach of the poorest. They are always at hand. Not always such as make you think upward, but of this class the supply is equal to every demand.

Without the slightest fear of successful contradiction I assert that the habit of reading good, thoughtful books is the unfailing road to self-culture and individual uplift and happiness. Again, it is the one habit which never fails to give the highest pleasure, the pleasure that brings lasting and helpful memories, the pleasure you can share with others, whether friends and acquaintances, or the members of your household—your wives and children. It is the one light in life that never fails, that shines in the darkest places, relieves the tedium of the sick room, and makes brighter by the higher conception not only this but the future life.

Take my word for it, gentlemen, that a good book is the best companion which a man can have. It matters not what a man's calling is, there will always be at least one hour of the twenty-four when he can enjoy his book. He can in spirit talk with it, study the motives and purposes of the author, compare the writer's views with his own, dissect it if he pleases, and fancy how he would have treated the same subject. Above all, if the opportunity is at hand talk with a friend of what you have read. As this habit of reading grows on you, it becomes the cherished delight of each day, and you approach your book with the same desire for mental exercise that you do your bed for physical rest.

Of course, much depends upon your selection of a book. But if it is fiction you desire you cannot err in selecting Scott, Thackeray, Washington Irving or Nathaniel Hawthorne. They are easily attainable and in pocket editions. If poetry, then again Scott, for his prose and poetry are perennial. They delight us in youth, middle-age, and even the chimney-corner period of life. Longfellow, Whittier, Edgar Poe, among our own poets, will afford an ample satisfaction to the most exacting. If history, then Green's "Short History of the English People," a book which contains more and better material in briefer compass than any I know. Among our own historians none can read Motley and Prescott without realizing their brilliancy and value. If all forms of literary entertainment are desired in two books, then the Bible and Shakespeare. The man who has these two at his mental call is not only the man whose silent moments are happy, but a man who is a power among men and never lonely with himself. He is a man whose brain daily undergoes conscious expansion; for remember, gentlemen, that the human mind is the part of God's creation which continues to grow after the body stops and grows feeble.

I had the pleasure of intimate acquaintance with a lawyer who knew Shakespeare and the Bible almost by heart. He literally lived in the atmosphere of these two books. His thoughts and feelings were colored by them, and I assure you he was before court and jury lofty, forcible, instructive, and, therefore, formidable.

In conclusion, I ask you to try my suggestion for a month. Get a fine book, devote an hour each day to it, and tell me at the end of that time if you have not been conscious of improving yourself. Yes, and conscious that you are better able to meet your daily duties; better able to understand and withstand some at least of the many efforts of charlatans and demagogues who trade on the supposed ignorance of the unthinking. You and all who study self-culture will gradually uplift the standard of citizenship until it attains a plane which will afford no place for those who are false teachers.

Railroad Fuel Men to Organize.—A circular letter is being issued inviting all purchasing and fuel agents, fuel supervisors, fuel accountants, and chief clerks to heads of departments handling fuel on railroads, to attend a meeting to be held in the Parlors of the Auditorium Annex Hotel, Chicago, on November 20, at 10 A. M., for the purpose of organizing an association. Such an association could properly take up and discuss the best and proper methods of handling, inspecting, weighing, distributing and accounting for fuel and oil. Those wishing to attend this meeting are requested to address Eugene McAuliffe, general fuel agent, Rock Island-Frisco Lines, La Salle Street Station, Chicago, Ill., who is chairman of the organization committee.

B. of L. E. Building.—The Brotherhood of Locomotive Engineers is to have a home of its own. Mr. W. S. Stone, grand chief, has announced that it has been decided to erect a building in Cleveland, Ohio, for a home office, the building, equipment, etc., to cost about a million dollars. It is to be twelve stories high and modernly equipped throughout, besides having a large auditorium with a seating capacity of about 1,600 or 1,800. This organization now has a membership of over 63,000.

COMBINED SIMPLE AND COMPOUND LOCOMOTIVE.

COMPARATIVE TRIALS OF SIMPLE AND COMPOUND LOCOMOTIVES.

Great Northern Railway (England).

In 1906, Mr. Henry A. Ivatt, locomotive superintendent of the Great Northern Railway of England, carried on a most carefully conducted series of trials, in regular service, of three locomotives which were entirely comparable in every respect, except the arrangement of cylinders and the steam distribution. The results of these trials was reported before the Institution of Mechanical Engineers by Mr. Ivatt and are given later in this account.

We have been fortunate in obtaining from Mr. O. V. P. Bulleid, assistant works manager of the locomotive department of the Great Northern Railway at Doncaster, some general drawings and information concerning the design of the locomotives under trial which permits the results of the trials to be much better appraised.

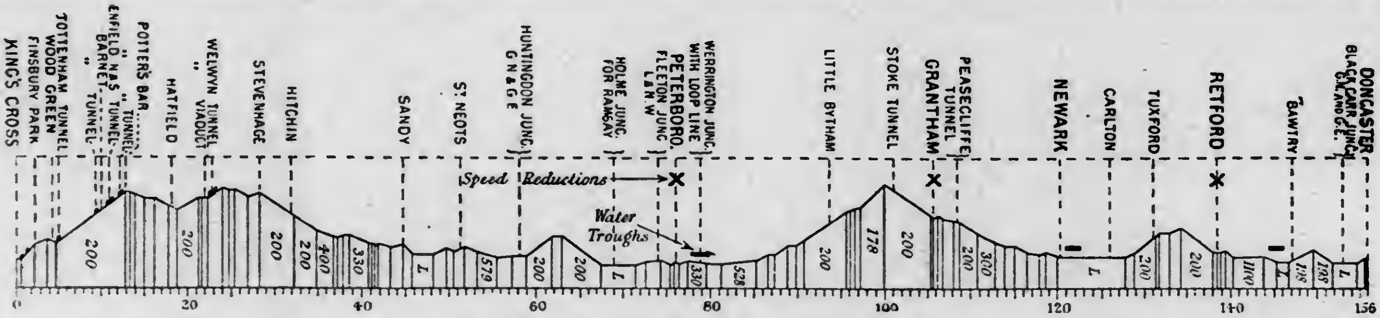
Of the three locomotives tested No. 1300 is four cylinder balanced compound Atlantic type, having a narrow fire box, built by the Vulcan Foundry Co. No. 292 is a four-cylinder combined compound or simple Atlantic type locomotive with a wide fire box, which was designed and built by the Great Northern Railway, as was also No. 294, which is a two-cylinder simple Atlantic type with a wide fire box. All of these engines, as will be seen by reference to the table of dimensions, are practically equal in weight and power and permit a fair comparison to be obtained between simple and compound working.

Locomotive No. 1300 is a compound of the DeGlehn type with cylinders 14 and 23 x 26 in., having piston valves on the high and slide valves on the low pressure cylinders. The high pressure cylinders on the outside of the frames connect with the rear driving wheels and the low pressure, placed just below the smoke box between the frames, connect with the cranked axle of the front pair of drivers. The steam pipe passes down inside of the front end and emerges just underneath the barrel of the boiler and between the frames, being continued by a

SIMPLE ATLANTIC TYPE LOCOMOTIVE.

curved pipe to the high pressure steam chest. The locomotive is fitted with a variable exhaust nozzle and with gridiron type of throttle valve. Each wheel has its own individual spring rigging and the weight is not equalized between the different wheels. In this respect the three locomotives are alike. The fire box gives 31 sq. ft. of grate area, setting between the plate frames and having a very deep throat. The boiler tubes are of the Serve type with 7 ribs. They are 2¾ in. diameter and are set with 1 in. bridges. The tubes occupy 31 per cent. of the barrel at the smoke box end. The general dimensions of the locomotive are given in the accompanying table. From these

DEGLEHN COMPOUND LOCOMOTIVE.



PROFILE OF ROAD OVER WHICH TEST WAS MADE.

and reference to the description of a similar locomotive built for the Paris-Orleans Railway by the American Locomotive Company, given elsewhere in this and the September issue of this journal, a good idea of the construction of No. 1300 will be obtained.

Locomotive No. 294 is a simple engine built at Doncaster, which has the dimensions given in the accompanying table. With the exception of the cylinders and their attachments, this locomotive does not differ in any essential feature from No. 292, the details of which are illustrated herewith.

Locomotive No. 292 is of the balanced compound type, but of new and very novel construction, as will be seen by reference to the accompanying drawings. All four cylinders are located below the smoke box with the high pressure outside and the low pressure between the frames. The high pressure cylinders, which are 13 in. in diameter and have a stroke of 20 in., connect by means of a 10 ft. connecting rod to the rear pair of drivers. The low pressure, or inside cylinders, which are 16 x 26 in., connect to the cranked axle of the forward pair of drivers, having connecting rods but 4 ft. 8 in. in length. Each cylinder has its independent valve gear, the outside gear being of the Walschaert type and the inside of the Stephenson design. Slide valves are used throughout, those for the low pressure being set vertically between the two cylinders.

A manually operated intercepting valve, which is shown in section in the longitudinal section of the locomotive, is provided, which permits the continuous operation of the locomotive as either a four-cylinder simple or a four-cylinder compound. This valve simply changes the connection between ports, so that in simple working, a passage is opened for steam at boiler pressure to pass through the connection in the front end to the opposite low pressure steam chest while the exhaust of the high pressure steam is permitted to go to the stack. For compound working this valve is shifted and cuts off the high pressure steam passage and sends the exhaust from the high pressure cylinder through the pipe to the low pressure cylinder on the opposite side. These pipes in the front are of the same length and act somewhat as reheaters for the steam going to the low pressure cylinder. Although the two cylinders do not differ greatly in diameter they have a volume ratio of nearly 1 to 2.

These locomotives have the smallest possible rigid wheel base, 82 in., the flanges of the driving wheels just clearing when new. The trailing truck consists simply of outside journal boxes having ½ in. side play in the pedestals on the supplementary trailing frame.

The spring rigging of this locomotive is interesting and contains no system of equalizers. The front drivers have semi-elliptical springs, while the back pair of drivers have helical springs. The engine truck has helical springs, while the trailing truck has elliptical springs over the outside journals. Auxiliary rubber cushions are used throughout and will be noticed at the bottom of the spring hangers.

The boiler is of the straight type, measuring 64½ in. outside diameter at the front end. The inner fire box is copper and the iron tubes have copper ends brazed on for connection at the flue sheet. The tubes have a rise of 2 in. toward the smoke box end and are expanded at both ends. They have steel ferrules for protection at the fire box end. The fire box is fitted with a

GENERAL DIMENSIONS OF LOCOMOTIVES TESTED.

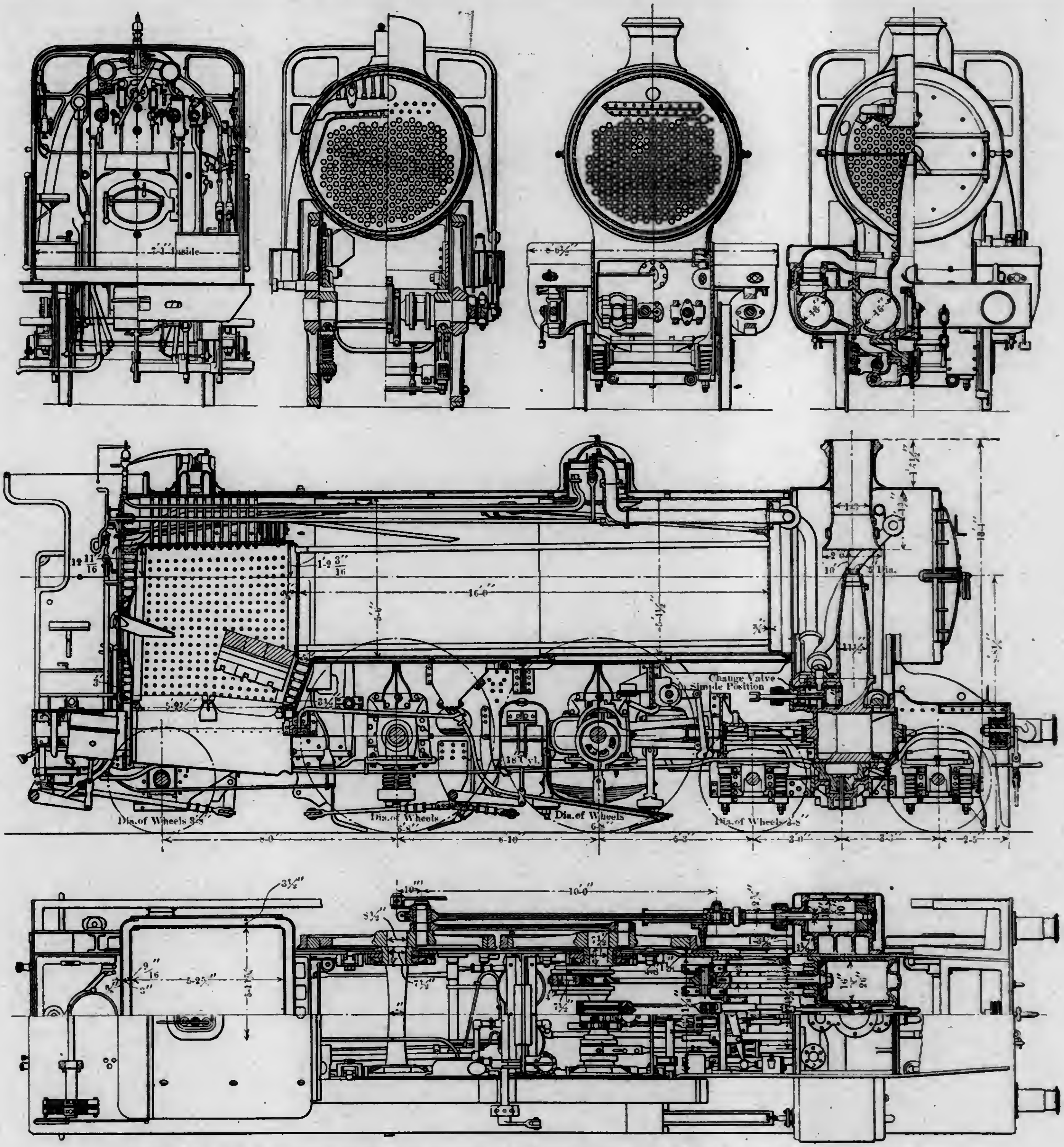
Locomotive Number	1,300	292	294
Tractive effort*, lbs.	14,869	8,994	16,875
Tract. effort, 292 as simple, lbs.	......	20,070	......
Weight in working order, lbs.	159,040	153,440	152,990
Weight on drivers, lbs.	82,880	80,640	80,640
Weight of engine and tender in working order, lbs.	250,660	245,060	244,610
Wheel base, driving	8 ft. 6 in.	6 ft. 10 in.	6 ft. 10 in.
Wheel base, total	28 ft. 3 in.	26 ft. 4 in.	26 ft. 4 in.
Wheel base, engine and tender	49 ft. 6 in.	48 ft. 5½ in.	48 ft. 5½ in.
RATIOS.			
Cylinders	2.7	1.96	......
Weight on drivers ÷ tractive effort (292 comp.)	5.5	8.96	4.78
Total weight ÷ tractive effort (292 comp.)	10.69	17.06	9.07
Tractive effort x diam. drivers ÷ heating surface	473.	287.8	540.
Total heating surface ÷ grate area	81.1	80.64	80.64
Tube heating surface ÷ firebox heating surface	13.79	16.73	16.73
Weight on drivers ÷ total heating surface	32.96	32.26	32.26
Total weight ÷ total heating surface	63.26	61.38	61.2
Volume both cylinders, cu. ft.	17.14	9.12	7.67
T'l heat. surf. ÷ vol. cylinders	146.6	274.12	325.94
Grate area ÷ vol. cylinders	1.8	3.39	4.04
CYLINDERS.			
Number	4	4	2
Kind	Compound.	Comp. or Simp.	Simple.
Diameter and stroke, inches	14 & 23 x 26	13 & 16 x 20 & 26	18¾ x 24
VALVES.			
Kind, H. P.	Piston.	Bal. Slide.	Bal. Slide.
Kind, L. P.	Bal. Slide.	Bal. Slide.	....
Greatest travel, inches	5⅜	4⅜	4⅛
Outside lap, H. P., inches	⅞	1	1 3/16
Outside, lap, L. P., inches	⅞	15/16	......
Inside clearance, inches	......	⅛	⅛
Lead in full gear, H.P., inches	¼	⅛	1/16
Lead in full gear, L.P., inches	¼	1/16	....
WHEELS.			
Driving, diam. over tires, inches	80	80	80
Driving journals, main, diameter and length, inches	8½ x 9	7½ x 7	8½ x 9
Engine truck wheels, diam., in.	38	44	44
Engine truck, journals, in.	5¾ x 9	5¾ x 9	5¾ x 9
Trailing truck wheels, diam., in.	44	44	44
Trailing truck, journals, in.	5½ x 10	5½ x 10	5½ x 10
BOILER.			
Working pressure, lbs.	200	200	200
Outside diam. of 1st ring, in.	63	66	66
Firebox, length and width, in.	129x18½	71x81	71x81
Firebox plate, thickness, in.	⅝	9/16	9/16
Firebox, water space, in.	3 & 3½	3 & 3½	3 & 3½
Tubes, number and outside diameter, in.	149-2¾	248-2¼	248-2¼
Tubes, length	12 ft. 4 in	16 ft.	16 ft.
Heating surface tubes, sq. ft.	2344	2359	2359
Heating surface firebox, sq. ft.	170	141	141
Heating surface, total, sq. ft.	2514	2500	2500
Grate area, sq. ft.	31	31	31

* For Simple .... $T.P. = \dfrac{0.8\ P\ d_h^2\ s_h}{D}$

For Compound .... $T.P. = \dfrac{1.6\ P\ d\ s_l}{D\,(r+1)}$

For No. 292 working Simple $T.P. = \dfrac{0.8\ F}{D}\ (d_h^2 \times s_h + d_l^2 \times s_l)$

Where D = Diameter of Driving Wheel, inches.
d_h = Do. High Pressure Cylinder, inches.
d_l = Do. Low Pressure Do. Do.
P = Boiler Pressure in lbs. per square inch.
s_h = Stroke of High Pressure Cylinder, inches.
s_l = Do Low Pressure Do. Do.
r = Ratio of Cylinder Volumes.



SECTIONS OF COMBINED COMPOUND AND SIMPLE LOCOMOTIVE—GREAT NORTHERN RAILWAY (ENGLAND).

brick arch and in addition a steel deflector is arranged over the fire door. The grates are in two sections, and are of the stationary type. In the front end the inside stack, or cowl, as it is called abroad, has an annular passage near the bottom, with a large number of ½ in. holes projecting upward toward the top of the stack. This is arranged for the exhaust of the steam ejector of the vacuum brake.

An inspection of the illustrations will reveal other interesting features of this design, which in many ways represent a very decided departure from standard practice as known in this country.

TRIALS.—The tests or trials of these locomotives were made for the purpose of determining the saving, if any, that could be obtained by the use of the compound locomotive in actual everyday practice, covering a long period of time. The trials took place between London and Doncaster, a profile of which line is shown in one of the illustrations. They were so arranged that each engineer and fireman of the three sets of men selected should run each engine for three weeks, with the same group of trains (mostly express), in regular rotation. In this way each engineer made the same number of trips with each engine on each train and the personal equation was practically eliminated. The crew ran each engine for one week prior to beginning the three weeks' trial, in order to get perfectly familiar with them.

The engines were put into the same condition of repair before the trials and were treated in the same way throughout. They were supplied with exactly the same quality of coal and an inspector on each engine throughout the trials took careful account of the coal and water, time lost or made up, condition of the weather, weight and composition of the trains and the cost of running repairs. The results of these trials are given in the following table, which was presented before the Institution of Mechanical Engineers:

	Engine No. 1300.	Engine No. 292.	Engine No. 294.
Miles run, Engine	11,286	11,670	11,673
Miles run, Train	11.045	11,415	11,415
Speed, Average miles per hour.	49.2	49.9	49.58
Weight of Train, Average tons.	229.98	238.03	234.29
Ton Miles:—			
Total Train	2,540,130	2,717,112.5	2,674,420
Including Engine and Tender.	3,803,030	3,993,812	3,949,110
Per hour, Engine and Tender.	16,759	17,337	17,030
Coal Used:—			
Per engine-mile, lbs	44.86	43.02	44.31
Per train-mile, lbs	45.84	43.98	45.31
Per ton-mile, lbs	0.133	0.126	0.131
Oil Used:—			
Per 100 engine miles, pints	7.34	7.18	6.22
Per 100 ton-miles, pints	0.022	0.021	0.0184
Costs:—			
Coal—			
Per engine-mile, pence	2.4	2.3	2.37
Per ton-mile, pence	0.0071	0.0067	0.007
Oil:—			
Per engine-mile, pence	0.165	0.16	0.14
Per ton-mile, pence	0.00049	0.00047	0.00041
Repairs:—			
Per engine-mile, pence	0.56	0.45	0.37
Per ton-mile, pence	0.0017	0.0013	0.0011
Total:—			
Per engine-mile, pence	3.125	2.91	2.88
Per ton-mile, pence	0.0092	0.0085	0.0085

LOCOMOTIVE WHEEL FLANGE LUBRICATOR.

Because of the numerous sharp curves on certain divisions of practically all the railroads in the country, an excessive amount of trouble is caused by worn flanges of locomotive driving and truck wheels. Incidentally an excessive amount of wear is also given to the rails, compelling their frequent renewal. It is easy to understand that if the inner part of the flange of the wheel or

DRIVING WHEEL FLANGE LUBRICATOR.

the inside face of the rail could be properly lubricated a very large proportion of this wear would be eliminated.

A lubricator for exactly this purpose has been designed and is being manufactured by the J. C. Martin Sons Co., San Francisco, Cal., which is shown, as applied to a locomotive driving wheel, in the accompanying illustration. This device has proved to be capable of remarkable results in actual service and is in use on quite a number of railroads of the Southwest and in Mexico. It has been found to be particularly valuable when applied to the trailing wheels of Pacific type locomotives.

The arrangement consists of a shoe which fits over the flange, being held in place by a couple of coiled springs and guided by a yoke attached to the frame. Provision is made for accommodating the movement of the wheel by allowance between the guide yoke and the guides, as well as by the compression of the springs. The interior of the shoe is hollow, the open section extending from the top to the throat of the flange and being filled with an absorbent material, which thus lubricates simply the bearing surface of the flange. Crude oil has been found to work the best and the supply is kept in a tank in the cab, being fed to the shoe by gravity, there being a sight feed valve convenient to the engineer, or fireman, which, when once properly set, requires no further attention.

Comparative tests have shown a reduction of 60 per cent. in the wear on driving wheel flanges by the use of this lubricator.

Bureau of American Manufacturers in Europe.—A bureau bearing the above name has recently been organized and is open to all reputable American firms. It has leased a six-story building in the business center of London where visiting buyers can always see an exhibition of American goods. A monthly bulletin is to be sent out to buyers in every quarter of the globe and personal letters will be distributed to them at frequent intervals. In fact, every mode of advertising consistent with progressive business methods will be employed to make the exhibit a profitable enterprise to the members. A staff of experienced salesmen will be engaged who will be specially trained in the lines to be demonstrated and buyers will be served as carefully and thoroughly as would be possible in the home offices of the respective members. Those interested in this movement can obtain full information by addressing Pitt & Scott, Ltd., 35 Broadway, New York.

The Flat Cars from which spoil is plowed on the Lidgerwood system of the Panama Canal are now being provided with a side extension which practically carries the floor about 15 in. over the side on which the spoil is dumped. According to the *Canal Record* experience shows that this extension enables the cars to be loaded more heavily and also dumps the material farther away from the trucks. Another improvement made in such cars is the use of a hinge and support which brings the aprons that connect two cars below the level of the floor, thus doing away with the trouble formerly experienced in having the aprons torn off by the plows.

Nine-Horse-Power Gasoline Engine vs. Two 50-Horse-Power Electric Motors.—The Big Four Railroad has recently completed a Scherzer rolling lift bridge across the Cuyahoga River at Cleveland, O. This is a double track structure, the lifting span, located about 70 feet above the water level, being about 160 feet long and crossing the river at an angle of 62 degs. The bridge is operated by two direct current electric motors of 50 h.p. each. For emergency work, in case of trouble with the electrical equipment or current, there has been installed a 9 h.p. Fairbanks-Morse gasoline engine, which will lift the bridge in twelve minutes, doing the work of the two 50-h.p. motors.

A Gasolene Motor of Unusual Lightness has recently been built by the Adams Co., Dubuque, Ia., for airship purposes, the complete engine, a five-cylinder 36-h.p. motor, weighing but 2.7 lb. per horse-power of its capacity. It utilizes the Adams-Farwell revolving-cylinder gyroscopic motor construction, the five cylinders revolving around a single-throw crank-shaft, which renders a flywheel unnecessary and so facilitates the cooling of the cylinders that air cooling flanges are not needed.

Master Mechanic Scholarships.—The scholarships which the American Railway Master Mechanics' Association maintains at Stevens Institute of Technology were this year awarded to the following men in the entering class: Mr. R. T. Branch, of Brooklyn; Mr. G. L. Clouser, of Jersey City, and Mr. L. B. Paterson, of Cranford, N. J.

A NEW 4 FOOT RADIAL DRILL.

A number of interesting features and improvements have been introduced in the new radial drills built by the Dreses Machine Tool Co., Cincinnati, O. These drills are based on the previous designs of this company and many of the older time-proven features have been retained.

The accompanying illustrations show the construction of several parts of the 4-foot drill very clearly. The double column is interesting and is shown in Fig. 2. The inner column is stationary and the outer shell turns on roller bearings. These bearings have small and large rollers alternating so that there is no slipping friction between the load carrying rollers. It will also be noted that the clamping band grips the inner and outer column, but exerts no pressure on the bearing.

The spindle sleeve is made of bar steel and the bearings are lined with phosphor bronze bushings. The rack is cut directly on the sleeve, which not only allows a perfectly round hole to be bored and reamed in the head stock for the sleeve, a great advantage in itself, but also brings the pressure on the rack closer to the center of the spindle.

There are four changes of feed, which are operated by a small handle shown on the worm shaft. The feed is of the all-geared type, but a frictional connection is interposed which yields just before the breaking point of the weakest gear. The lever, shown just below the arm, starts, stops or reverses the spindle by means of the friction clutch. The back gears are on the rear of the head stock and can be engaged or disengaged while the machine is running.

The speed variator is so arranged that the machine is always running at the slowest speed when speed changes are being made, thus preventing the sudden change in momentum which would follow starting from a stopped condition. In this speed variator, a section of which is shown in Fig. 3, a new overrunning clutch has been introduced, which is shown in detail in Fig. 4. The gear, B, runs loose on the variable speed shaft and is internally clutched by four pawls, P, located in the fixed gear, C. These pawls are kept in contact with the gear by means of the spiral springs, S, and by limiting their faces to 5/16 in. of circumferential width they will clutch the gear, B, to gear, C, when running in the direction of the arrow, but will release when C runs faster than B.

All of the high speed bearings in the machine are lined with removable phosphor bronze bushings and all of the bevel gears

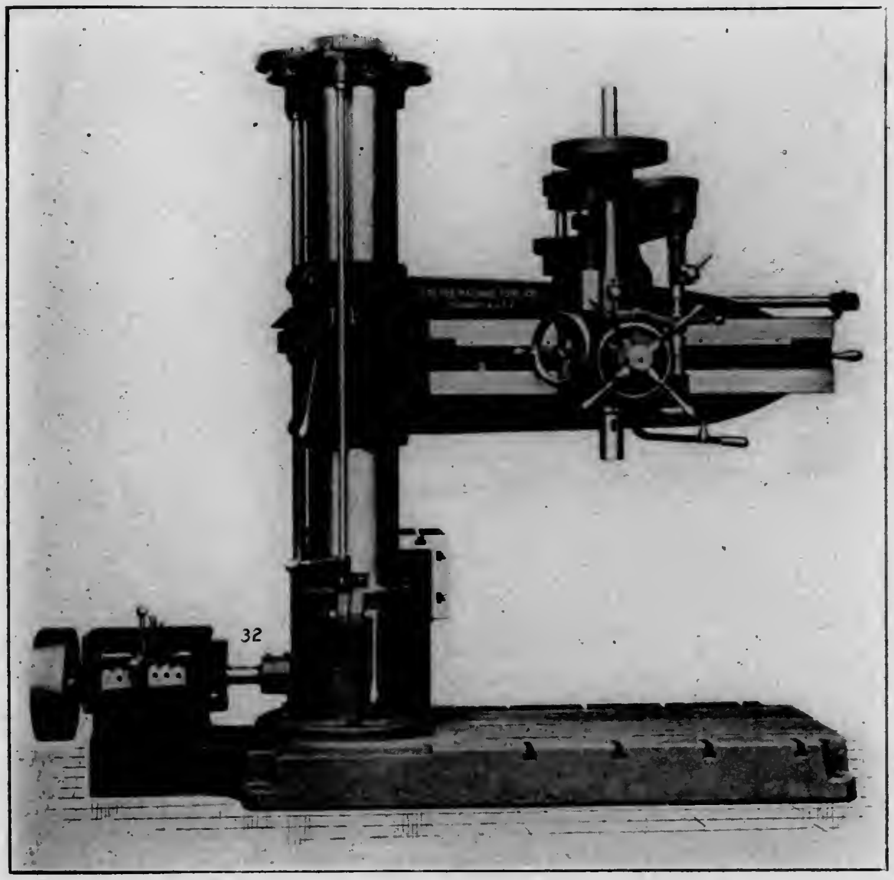


FIG. 1.—NEW FOUR-FOOT RADIAL DRILL.

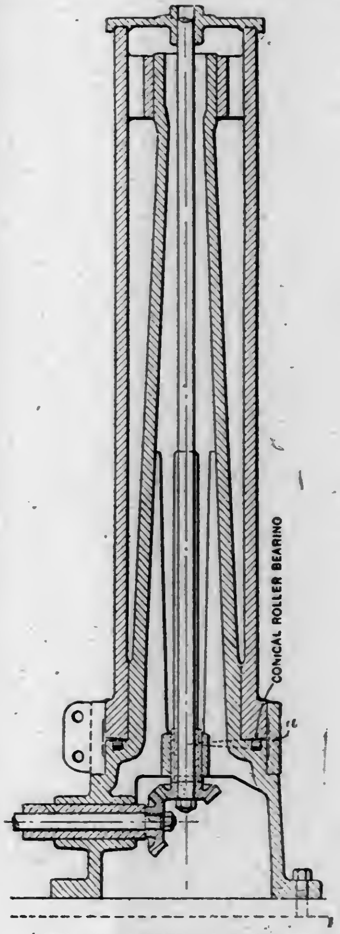


FIG. 2.—DETAIL OF COLUMN.

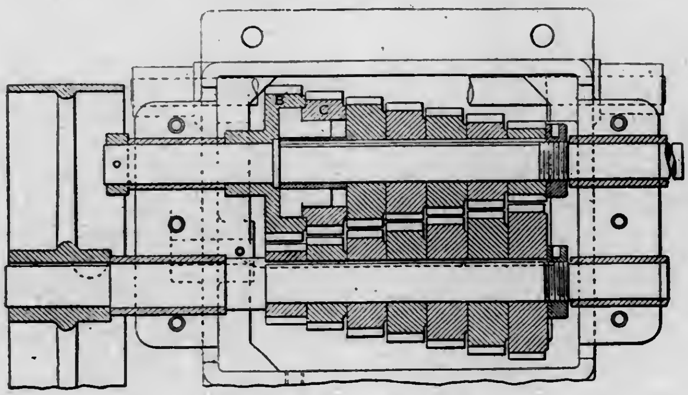


FIG. 3.—SPEED VARIATOR.

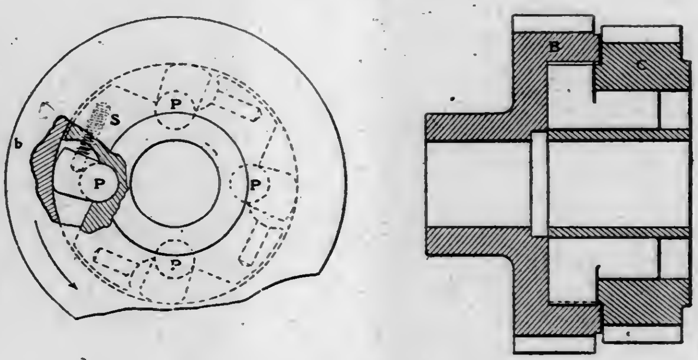


FIG. 4.—OVERRUNNING CLUTCH.

	Engine No. 1300.	Engine No. 292.	Engine No. 291.
Miles run, Engine	11,286	11,670	11,673
Miles run, Train	11,045	11,415	11,415
Speed, Average miles per hour	49.2	49.9	49.58
Weight of Train, Average tons	229.98	238.03	234.29
TON MILES:—			
Total Train	2,540,130	2,717,112.5	2,674,420
Including Engine and Tender	3,863,030	3,993,812	3,949,110
Per hour, Engine and Tender	16,759	17,337	17,030
COAL USED:—			
Per engine-mile, lbs	44.86	43.02	44.31
Per train-mile, lbs	45.81	43.98	45.31
Per ton-mile, lbs	0.133	0.126	0.131
OIL USED:—			
Per 100 engine miles, pints	7.31	7.18	6.22
Per 100 ton miles, pints	0.022	0.021	0.0184
COSTS:—			
Coal—			
Per engine-mile, pence	2.4	2.3	2.37
Per ton-mile, pence	0.0071	0.0067	0.007
Oil:			
Per engine-mile, pence	0.165	0.16	0.14
Per ton-mile, pence	0.00049	0.00047	0.00041
Repairs:—			
Per engine-mile, pence	0.56	0.45	0.37
Per ton-mile, pence	0.0017	0.0013	0.0011
Total:			
Per engine-mile, pence	3.125	2.91	2.88
Per ton-mile, pence	0.0092	0.0085	0.0085

LOCOMOTIVE WHEEL FLANGE LUBRICATOR.

Because of the numerous sharp curves on certain divisions of practically all the railroads in the country, an excessive amount of trouble is caused by worn flanges of locomotive driving and truck wheels. Incidentally an excessive amount of wear is also given to the rails, compelling their frequent renewal. It is easy to understand that if the inner part of the flange of the wheel or

DRIVING WHEEL FLANGE LUBRICATOR.

the inside face of the rail could be properly lubricated a very large proportion of this wear would be eliminated.

A lubricator for exactly this purpose has been designed and is being manufactured by the J. C. Martin Sons Co., San Francisco, Cal., which is shown, as applied to a locomotive driving wheel, in the accompanying illustration. This device has proved to be capable of remarkable results in actual service and is in use on quite a number of railroads of the Southwest and in Mexico. It has been found to be particularly valuable when applied to the trailing wheels of Pacific type locomotives.

The arrangement consists of a shoe which fits over the flange, being held in place by a couple of coiled springs and guided by a yoke attached to the frame. Provision is made for accommodating the movement of the wheel by allowance between the guide yoke and the guides, as well as by the compression of the springs. The interior of the shoe is hollow, the open section extending from the top to the throat of the flange and being filled with an absorbent material, which thus lubricates simply the bearing surface of the flange. Crude oil has been found to work the best and the supply is kept in a tank in the cab, being fed to the shoe by gravity, there being a sight feed valve convenient to the engineer, or fireman, which, when once properly set, requires no further attention.

Comparative tests have shown a reduction of 60 per cent. in the wear on driving wheel flanges by the use of this lubricator.

BUREAU OF AMERICAN MANUFACTURERS IN EUROPE.—A bureau bearing the above name has recently been organized and is open to all reputable American firms. It has leased a six-story building in the business center of London where visiting buyers can always see an exhibition of American goods. A monthly bulletin is to be sent out to buyers in every quarter of the globe and personal letters will be distributed to them at frequent intervals. In fact, every mode of advertising consistent with progressive business methods will be employed to make the exhibit a profitable enterprise to the members. A staff of experienced salesmen will be engaged who will be specially trained in the lines to be demonstrated and buyers will be served as carefully and thoroughly as would be possible in the home offices of the respective members. Those interested in this movement can obtain full information by addressing Pitt & Scott, Ltd., 35 Broadway, New York.

THE FLAT CARS from which spoil is plowed on the Lidgerwood system of the Panama Canal are now being provided with a side extension which practically carries the floor about 15 in. over the side on which the spoil is dumped. According to the *Canal Record* experience shows that this extension enables the cars to be loaded more heavily and also dumps the material farther away from the trucks. Another improvement made in such cars is the use of a hinge and support which brings the aprons that connect two cars below the level of the floor, thus doing away with the trouble formerly experienced in having the aprons torn off by the plows.

NINE-HORSE-POWER GASOLINE ENGINE vs. TWO 50-HORSE-POWER ELECTRIC MOTORS.—The Big Four Railroad has recently completed a Scherzer rolling lift bridge across the Cuyahoga River at Cleveland, O. This is a double track structure, the lifting span, located about 70 feet above the water level, being about 160 feet long and crossing the river at an angle of 62 degs. The bridge is operated by two direct current electric motors of 50 h.p. each. For emergency work, in case of trouble with the electrical equipment or current, there has been installed a 9 h.p. Fairbanks-Morse gasoline engine, which will lift the bridge in twelve minutes, doing the work of the two 50 h.p. motors.

A GASOLENE MOTOR OF UNUSUAL LIGHTNESS has recently been built by the Adams Co., Dubuque, Ia., for airship purposes, the complete engine, a five-cylinder 36 h.p. motor, weighing but 2.7 lb. per horse-power of its capacity. It utilizes the Adams-Farwell revolving-cylinder gyroscopic motor construction, the five cylinders revolving around a single-throw crank-shaft, which renders a flywheel unnecessary and so facilitates the cooling of the cylinders that air cooling flanges are not needed.

MASTER MECHANIC SCHOLARSHIPS.—The scholarships which the American Railway Master Mechanics' Association maintains at Stevens Institute of Technology were this year awarded to the following men in the entering class: Mr. R. T. Branch, of Brooklyn; Mr. G. L. Clouser, of Jersey City, and Mr. L. B. Paterson, of Cranford, N. J.

A NEW 4 FOOT RADIAL DRILL.

A number of interesting features and improvements have been introduced in the new radial drills built by the Dreses Machine Tool Co., Cincinnati, O. These drills are based on the previous designs of this company and many of the older time-proven features have been retained.

The accompanying illustrations show the construction of several parts of the 4-foot drill very clearly. The double column is interesting and is shown in Fig. 2. The inner column is stationary and the outer shell turns on roller bearings. These bearings have small and large rollers alternating so that there is no slipping friction between the load carrying rollers. It will also be noted that the clamping band grips the inner and outer column, but exerts no pressure on the bearing.

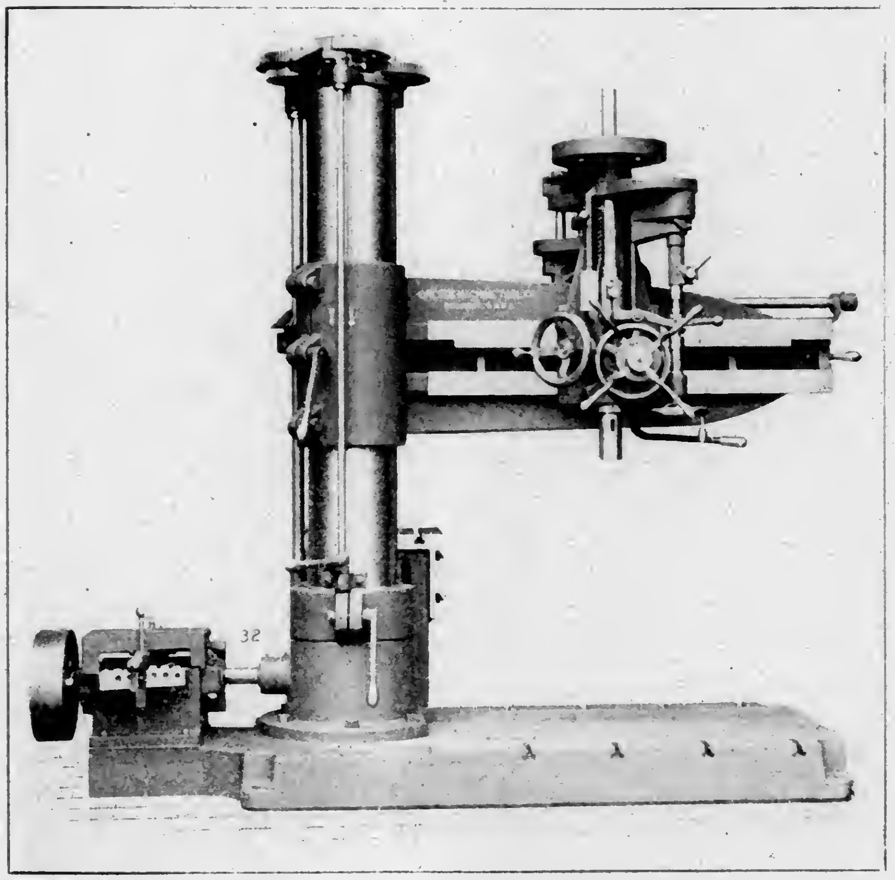


FIG. 1.—NEW FOUR-FOOT RADIAL DRILL.

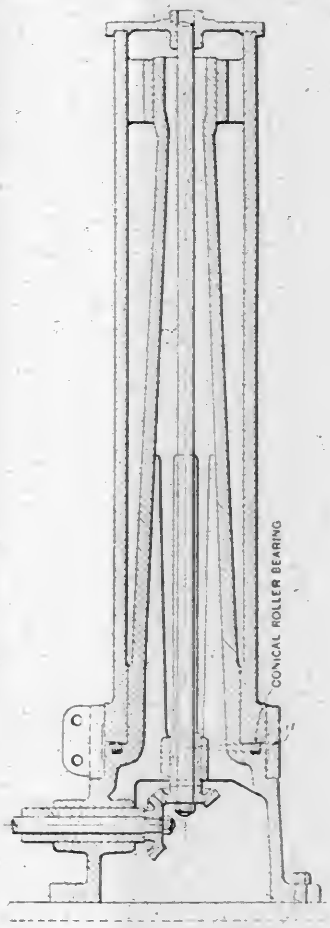


FIG. 2.—DETAIL OF COLUMN.

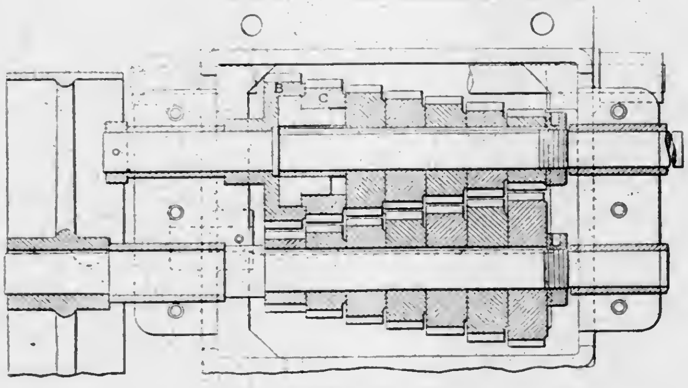


FIG. 3.—SPEED VARIATOR.

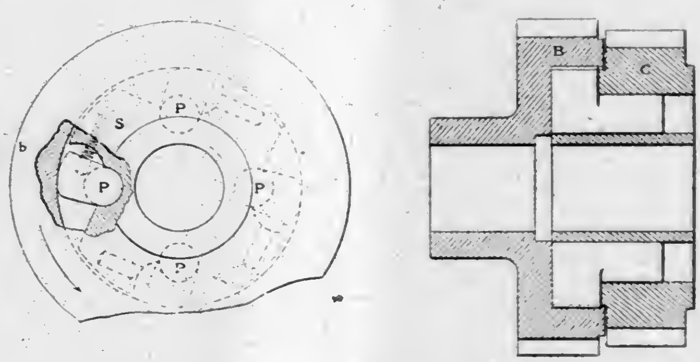


FIG. 4.—OVERRUNNING CLUTCH.

The spindle sleeve is made of bar steel and the bearings are lined with phosphor bronze bushings. The rack is cut directly on the sleeve, which not only allows a perfectly round hole to be bored and reamed in the head stock for the sleeve, a great advantage in itself, but also brings the pressure on the rack closer to the center of the spindle.

There are four changes of feed, which are operated by a small handle shown on the worm shaft. The feed is of the all-geared type, but a frictional connection is interposed which yields just before the breaking point of the weakest gear. The lever, shown just below the arm, starts, stops or reverses the spindle by means of the friction clutch. The back gears are on the rear of the head stock and can be engaged or disengaged while the machine is running.

The speed variator is so arranged that the machine is always running at the slowest speed when speed changes are being made, thus preventing the sudden change in momentum which would follow starting from a stopped condition. In this speed variator, a section of which is shown in Fig. 3, a new overrunning clutch has been introduced, which is shown in detail in Fig. 4. The gear, B, runs loose on the variable speed shaft and is internally clutched by four pawls, P, located in the fixed gear, C. These pawls are kept in contact with the gear by means of the spiral springs, S, and by limiting their faces to 5/16 in. of circumferential width they will clutch the gear, B, to gear, C, when running in the direction of the arrow, but will release when C runs faster than B.

All of the high speed bearings in the machine are lined with removable phosphor bronze bushings and all of the bevel gears

and pinions below 6 in. are of bar or forged steel. The elevating device of the arm is so designed that the gears are stopped when not in use. The arm itself is of box parabolic shape, the lower rib being double webbed to give the greatest resistance to bending and torsional strains. All of the gears which could possibly be dangerous to the operator have been encased.

Electricity Increases Traffic Capacity.—"The greatest value to be experienced by electrification will be in the tremendously increased traffic capacity of the present track mileages, due to the facility electricity offers in making rapid main line and yard train movement, or, stated in another way, it is thus immediately seen that electrification will permit a tremendous increase of traffic without an increase of traffic mileage, and thus roads which are up against the requirement of handling their congested traffic by laying new tracks, which, of course, is a most expensive procedure on account of right-of-way difficulties, will be led into providing an equal capacity by electrification of the old trackage."—*W. S. Murray, N. Y., N. H. & H. R. R.*

Monorail Electric Railroad.—The Monoroad Construction Company has purchased from the Interborough Rapid Transit Company of New York, the Pelham Park and City Island Railroad, which is about three miles in length and is at present operated by horses. It is proposed to convert this line to the Monorail system on which 50 ft. cars, pointed at each end and supported by four wheels having flanges on each side placed in tandem at either end, and guided by two overhead rails supported from a catenary system of suspension, will be operated.

C. P. R. Strike Ended.—Press despatches of October 6 report the strike of shop employees on the Canadian Pacific Ry., which began the first week in August, as settled. The strikers returned to work on the conditions that existed before the strike and the company announces that the new men will not be discharged, except for inefficiency.

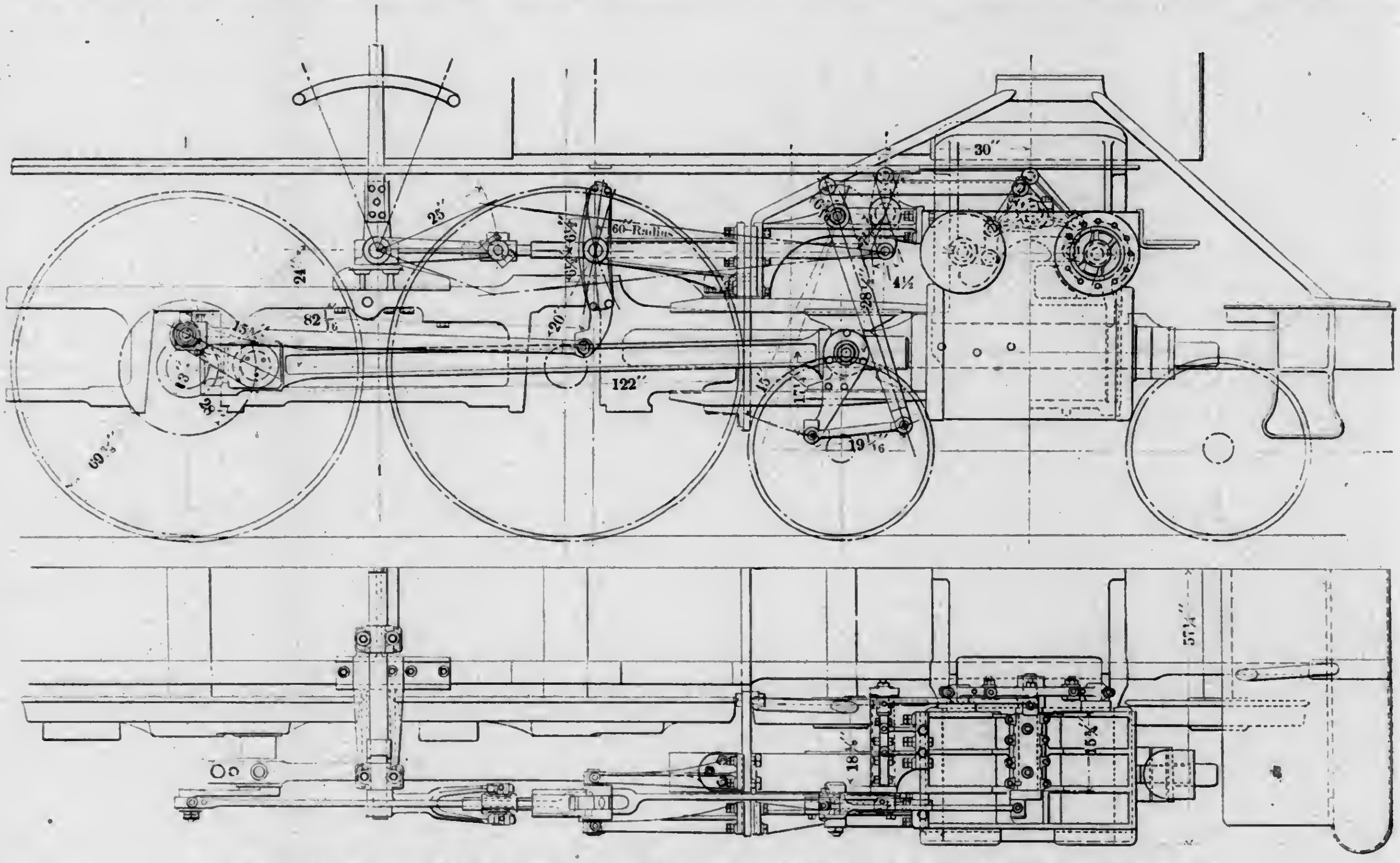
The law of New York State, requiring railroad companies to pay their employees semi-monthly, went into effect October 1.

NEW DESIGN OF YOUNG VALVE AND GEAR

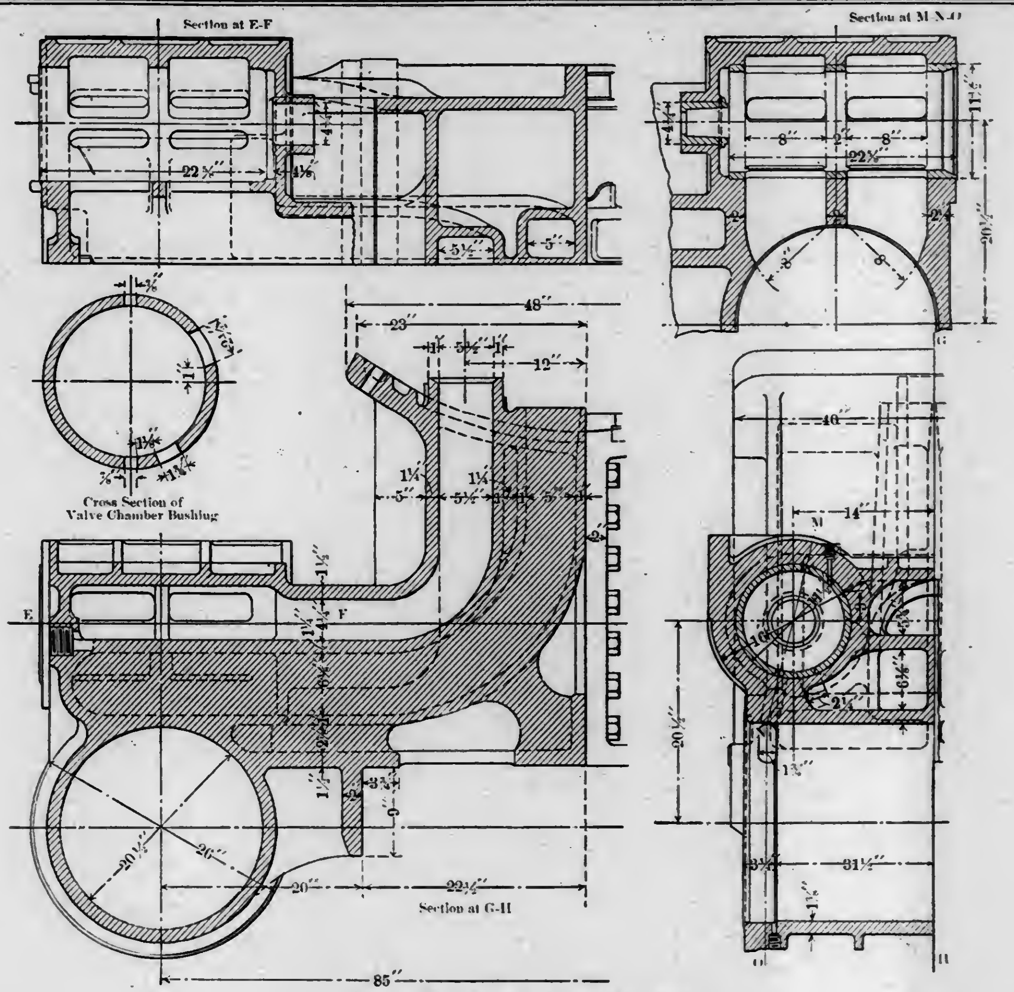
Delaware, Lackawanna & Western Railroad.

On page 65 of the February, 1906, issue of this journal appeared a very completely illustrated description of the Young valve and gear as applied to a 10-wheel locomotive on the Delaware & Hudson Railroad, the application being made in connection with the Stephenson type of valve gear. Recently a new design, using the same type of valve, with an entire alteration in the valve gear, which closely resembles the Walschaert type, has been applied to some locomotives on the Delaware, Lackawanna & Western Railroad, and is also being fitted to some locomotives of the Chicago & Northwestern Railroad now under construction. The former application is shown in the accompanying illustrations.

Briefly, this type of valve gear employs two rotary valves on each side of the locomotive, located above and with their axes at right angles to the axis of the cylinder. These valves are operated simultaneously from a wrist plate, which receives its oscillating motion from a connection to the eccentric or return crank through the medium of the link, by means of which reversing, the point of cut-off and other valve events are controlled in the usual manner. The fulcrum of this wrist plate is formed on one end of a bell crank, which, in a case of application with the Stephenson valve gear, was altered in position by a connection to the reverse shaft, but did not change its position except as the reverse lever and hence the cut-off was altered. In the latter design, however, this bell crank is operated from a combination lever connected to the cross head and having a stationary fulcrum, with the result that the position of the wrist plate fulcrum is constantly being changed at different points of the stroke and gives a material alteration of the point of occurrence of the steam events in the cylinder from what is usually obtained with the ordinary design of Stephenson or Walschaert valve gear. The effect of this combination of motions is that the valves have a constant lead for all points of cut-off, the early release of the Stephenson and Walschaert gear is maintained, but the point of exhaust closure is materially delayed and the opening of the valve ports during exhaust is very decidedly increased. The construction of the valve and steam passages is



YOUNG VALVE AND GEAR AS APPLIED TO DELAWARE, LACKAWANNA & WESTERN R. R. LOCOMOTIVE.



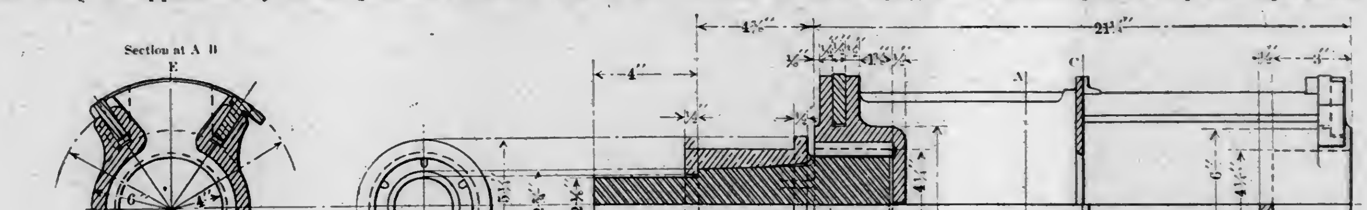
CYLINDERS FOR YOUNG VALVE AND GEAR.

such as to give a largely increased port opening, the port being equivalent to one 32 in. in length on a slide valve, which, taken in connection with the rapid movement of the valve at the point of cut-off, gives a very free admission and permits the pressure to be held up to the point of cut-off even at very high speeds. The principal gain, however, as relates to both speed and economy is in the much larger port openings for exhaust, particularly at the middle of the stroke when the piston is moving at its highest speed.

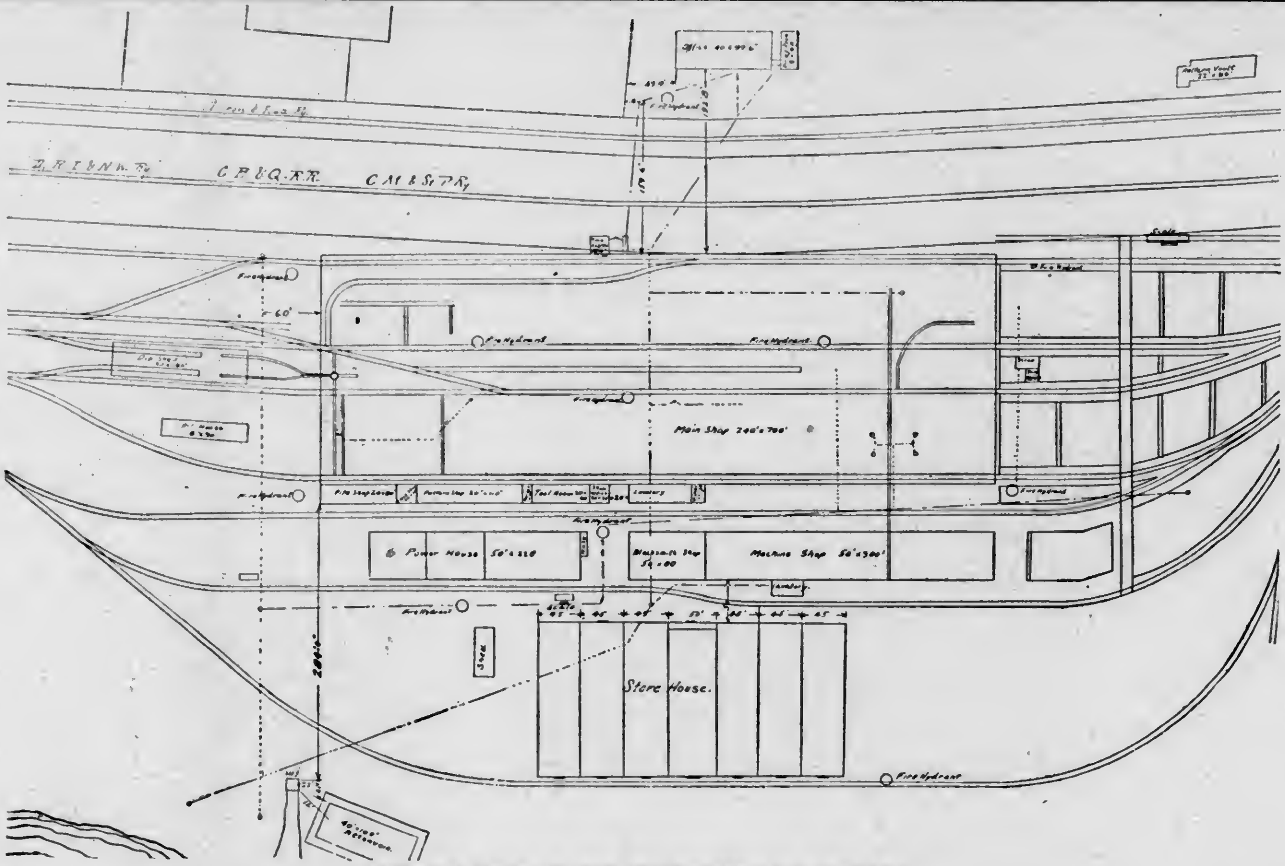
The construction of the cylinders and valves and arrangement of the gear, is clearly shown in the accompanying illustrations. It will be seen that the valve chambers are formed as part of the cylinder casting, the location being such as to give a very short and direct steam port from the bottom of the chamber, there also being a supplementary steam passage from the top of the valve chamber. The valves are 1 in. in diameter and 21¼ in. total length, and have been simplified somewhat over those used on the Delaware & Hudson locomotive above referred to. The valve, of course, is made as light as possible and its weight is carried by the bearings at either end, with the result that there is practically no wear on the bushings.

The valve gear in appearance is very similar to the ordinary Walschaert type, but differs from it, first, by having the combination lever arranged with a fixed fulcrum and by connecting the radius bar to a rocker, which transposes the motion from the plane of the return crank to the inside of the valve chambers, where the wrist plate and bell crank are located.

The application of this gear to the Chicago & Northwestern locomotives is an excellent testimonial of its value, since it was on this road, in 1903, that the first gear was put in operation.



DETAILS OF VALVES—YOUNG VALVE AND GEAR.



STEEL CAR PLANT OF THE BETTENDORF AXLE COMPANY.

A MODERN STEEL CAR PLANT.

The shops of the Bettendorf Axle Company, which is engaged in the manufacture of car equipment and the building of all-steel cars, have been very materially enlarged in the past few years to enable the company to handle its growing business. The new site at Bettendorf, a suburb of Davenport, Iowa, covers an area of 70 acres which are rapidly being utilized for manufacturing purposes. The layout, shown herewith, gives the arrangement of buildings and the excellent railroad connections which facilitate the operation of this plant.

The main shop of the plant, a building 700 x 240 feet in size, contains perhaps the most complete hydraulic plant in the country. All, or nearly all, of the shaping of the car parts is accomplished by the aid of hydraulic presses, of which there are upwards of sixty, varying in capacity from fifty to eighteen hundred tons. Some idea of the power developed can be gained when it is stated that in the largest of these presses 34-inch I-beams are shaped cold, *i. e.*, the ends are reduced and the beam is otherwise shaped and punched in various places without being heated; and all the smaller car parts, except the castings, are shaped and prepared for use in the same way. All special hydraulic machinery, used in this plant, was designed and built by the company.

Aside from the complete hydraulic plant, and in connection therewith, the works contain a full complement of other machinery operated by electric power and compressed air. There are eleven traveling cranes of varying capacity, which are electrically operated and enable the rapid assembling of the car parts. They were furnished mainly by the Pawling & Harnischfeger Company and the Cleveland Crane Company.

Much of the riveting (of sheets particularly) is done by compressed air, and this power is also made use of in finishing most of the car parts. A sand-blasting apparatus for cleaning the sheets and other parts of car, preparatory to painting, has been installed and is also operated by compressed air. A complete electric light plant furnishes light for the shops as well as for the office building some little distance away.

The operation of the main shop is from east to west. The hydraulic presses are located in the east end where the bolster and car parts are shaped and punched. The car and bolster riveting departments are in the west end of the shop. The castings are brought from the storehouse, south of the main shop, into the center of the shop where they are riveted to the steel bolster and car parts. The body and truck bolsters, steel underframes and all-steel cars are assembled, painted and shipped from the west end.

Immediately south of the main shop is the power house, 80 x 220 feet in size, part of which until recently was utilized as a machine shop. The six horizontal boilers, with an aggregate capacity of about 1,000 h.p., are in the west end of the building, and the engine room adjoining contains the pumps and machinery.

Still further to the south and east are the extensive store houses for the material, covering an area of several acres, and to the west is the paint shop and other minor buildings in a group by themselves. The D. R. I. & N. W. Ry., C. M. & St. P. Ry. and the C. B. & Q. Ry. run through the manufacturing tract, and excellent switching and yard facilities, including four tracks, running through the main buildings, have been obtained. Locomotive cranes facilitate the loading and unloading of materials in the yards and shops.

The machine shop, as has been stated, was until recently located in the power building, but the available space proving entirely inadequate for the purpose, it was last fall decided to erect a new machine shop directly east of the power house and south of the main shops. The new machine shop is a building 50 x 380 feet in size, of which the west 80 feet will be utilized for the blacksmith shop, leaving the size of the machine shop proper 50 x 300 feet.

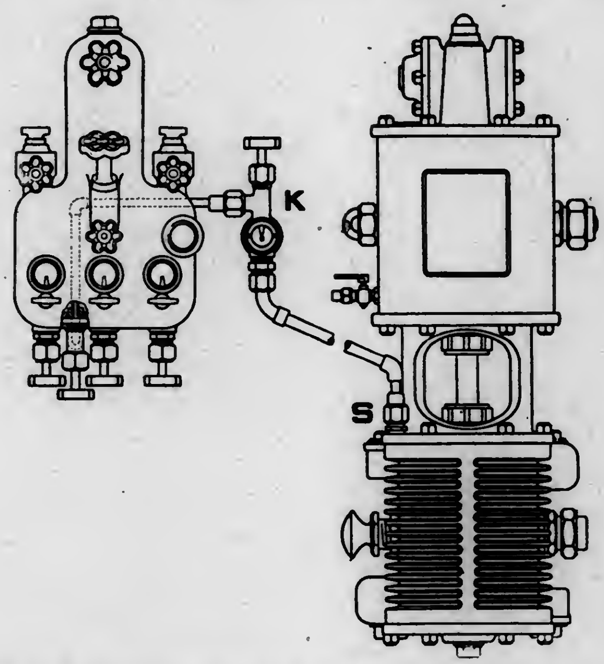
The office building of the company has also recently been enlarged by the addition of a second story, which will give more room for the clerical force.

To give an idea of the progress made by the Bettendorf company in the manufacture of railway equipment, it may be stated that starting in about ten years ago with the production of the I-beam bolsters in the old Davenport plant, there has since been added the manufacture of the Bettendorf steel car underframe, the cast steel truck with integral journal boxes, and finally complete tank and freight cars. The capacity of the present plant is 25 complete cars or forty steel underframes in a day.

SIGHT FEED AIR CYLINDER LUBRICATOR.

For the purpose of securing proper lubrication of the air cylinders of locomotive air pumps the Detroit Lubricator Company has designed a sight feed lubricator attachment which gives the engineer complete and convenient control of the lubrication of his pump. It consists of three parts: first, the emergency valve, which takes the place of the plug in the bottom of a Detroit lubricator. Next comes the sight feed fitting, which is equipped with regular bull's-eye glasses and can be located at any convenient point in the boiler head within reach of the engineer. The third fitting is a check valve connection, which takes the place of the present oil cup on the air cylinder and is provided with a ball check seating upwards, and prevents the compressed air from entering the oil delivery pipe. The illustration shows the arrangement and connections for these fittings.

The location of the sight feed fitting should be such as to give a gradual incline to the pipe leading to the check valve, so that the oil can flow by gravity to the pump. There must, however,



be a trap between the lubricator and sight feed fitting to prevent the water from entering the supply pipe after all the oil has been fed from the reservoir. To provide for this the oil supply pipe is extended upward from the emergency valve to about the same height as the upper part of the oil reservoir.

Provision is made for a double sight feed fitting for use with compound or duplex pumps. The makers of this device do not advise a constant feed of oil to the cylinders, but recommend that not more than ten drops of oil be fed at any one time and these at intervals, according to the judgment of the engineer.

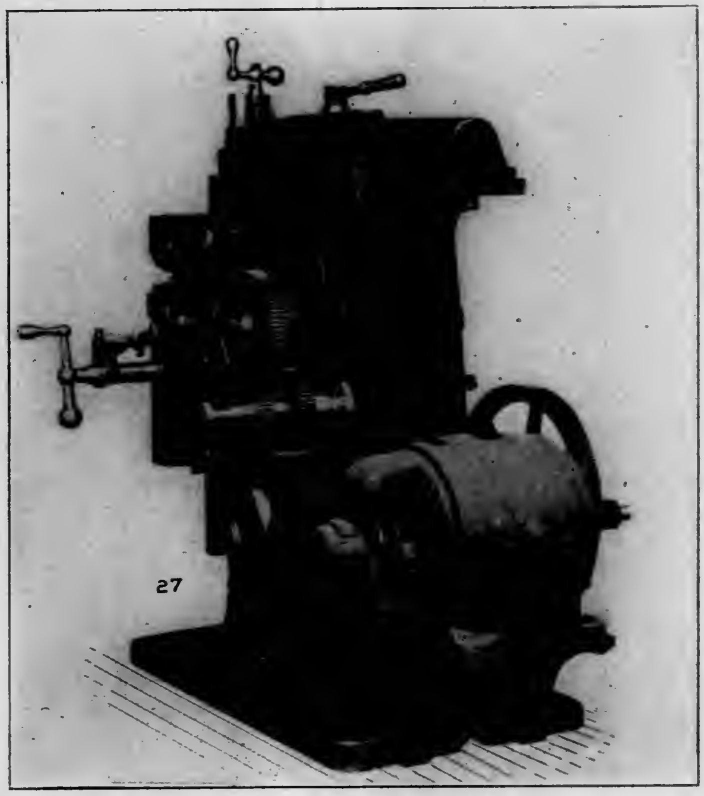
900,000 Patents.—The nine hundred thousandth patent from the United States Patent Office was issued September 29. It was granted too Charles D. Seeberger, of Yonkers, N. Y., and refers to an improvement on traveling stairs, such as are used in hotels and other large buildings. Mr. Moore estimates that the one millionth patent will be reached in the year 1911. The total of patents issued by the United States is not very far below the total for all other countries for all time.

"The Density of Traffic is, of course, the paramount feature as to the savings to be effected by electrification. It is not to be forgotten that, in electrifying, interest, depreciation, insurance and taxes follow closely on the heels of the capital investment in equipment and material necessary to electric operation. The heavier the traffic, the greater will be the economies derived from the two above mentioned sources."—*W. S. Murray, N. Y., N. H. & H. R. R.*

14-INCH CRANK SHAPER.

A crank shaper, which in mechanical construction differs from anything now on the market, has recently been brought out by the John Steptoe Shaper Company, of Cincinnati. This machine was built especially to economize on space, the original design being for use on a revenue cutter in government service, where the available room was exceedingly small. Reference to the illustration will show that the motor does not take up any extra room at all, being arranged to set on the base of the machine against the column, where it does not require any greater clearance than does the return stroke of the ram.

This is a 14 in. single geared machine driven by a 2½ h.p. motor. The pinion on the motor shaft is rawhide with brass flanges, being 2 in. in diameter and having 22 teeth. It meshes with the large gear 16 in. in diameter, with 190 teeth, giving a



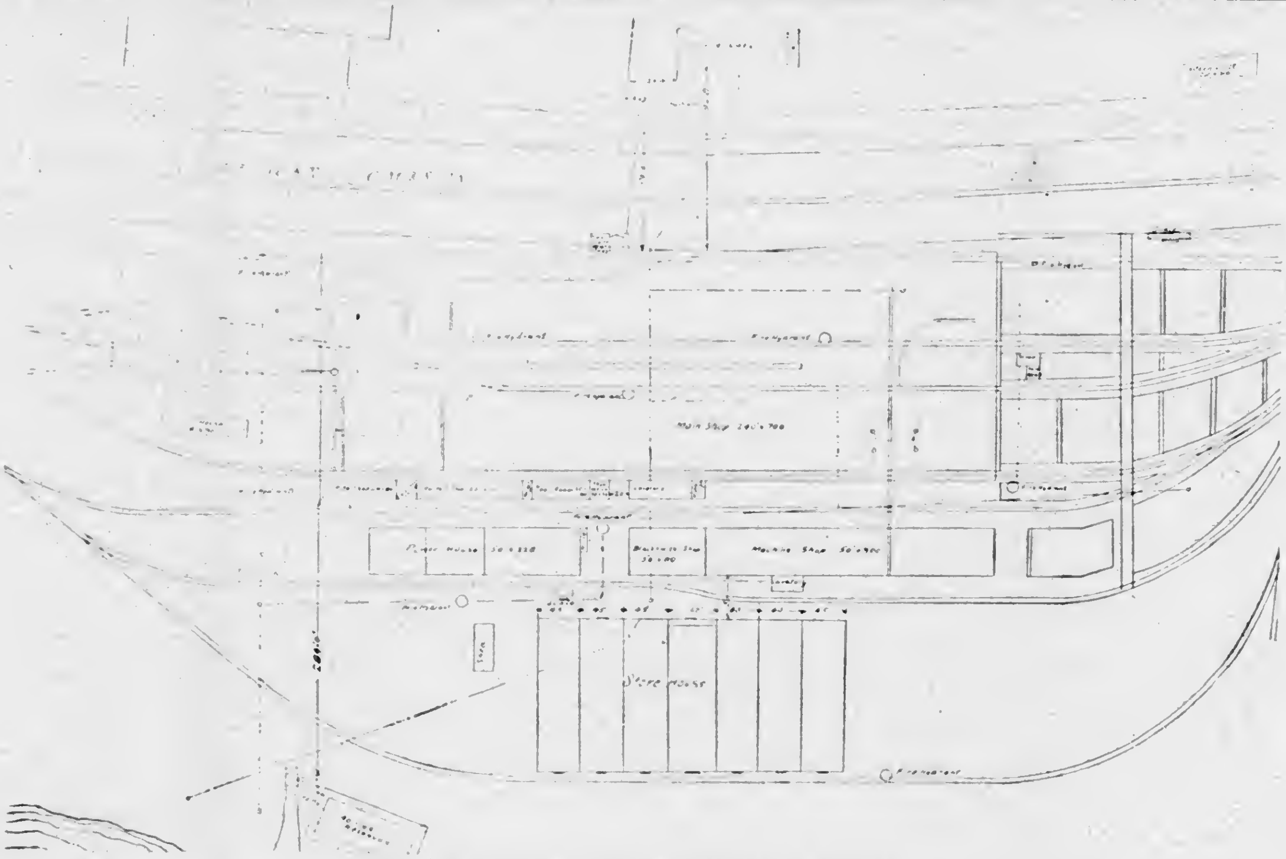
14-INCH CRANK SHAPER.

gear ratio of about 8 to 1. The shaft for the 16 in. gear has a 5 in. bearing on both sides of the column and carries at the opposite end the wide gear shown at the bottom of the train of gears in the illustration. This wide-faced gear is used in order to provide for the shifting of the compound gear arranged just above it. The compound gear contains a 6 and a 4 in. diameter wheel arranged on the same shaft so that when one is in mesh the other is thrown out. The hand wheel at the bottom is used to turn the gears sufficiently to make the compound gear mesh when it is shifted to change the speed.

The illustration shows the machine with the gear covers removed.

Mexican Railroads.—In a message to the Mexican Congress President Diaz says that 265 miles of new railroad have been built in Mexico in the last six months, and that on September 1 there was a total of 14,665 miles of railroad in the country. Practically all the new mileage is that of the Cananea, Yaqui River & Pacific Ry., which E. H. Harriman and his associates are building down the Pacific slope.

Chinese Railroads.—Since the war with Japan the mileage of the Chinese railroads has materially increased. Including the Manchurian railroads there are now 3,200 miles of road in operation, an equal amount projected and 1,100 miles building.



STEEL CAR PLANT OF THE BETTENDORF AXLE COMPANY.

A MODERN STEEL CAR PLANT.

The shops of the Bettendorf Axle Company, which is engaged in the manufacture of car equipment and the building of all-steel cars, have been very materially enlarged in the past few years to enable the company to handle its growing business. The new site at Bettendorf, a suburb of Davenport, Iowa, covers an area of 70 acres which are rapidly being utilized for manufacturing purposes. The layout, shown herewith, gives the arrangement of buildings and the excellent railroad connections which facilitate the operation of this plant.

The main shop of the plant, a building 700 x 240 feet in size, contains perhaps the most complete hydraulic plant in the country. All, or nearly all, of the shaping of the car parts is accomplished by the aid of hydraulic presses, of which there are upwards of sixty, varying in capacity from fifty to eighteen hundred tons. Some idea of the power developed can be gained when it is stated that in the largest of these presses 34-inch I-beams are shaped cold, *i. e.*, the ends are reduced and the beam is otherwise shaped and punched in various places without being heated; and all the smaller car parts, except the castings, are shaped and prepared for use in the same way. All special hydraulic machinery, used in this plant, was designed and built by the company.

Aside from the complete hydraulic plant, and in connection therewith, the works contain a full complement of other machinery operated by electric power and compressed air. There are eleven traveling cranes of varying capacity, which are electrically operated and enable the rapid assembling of the car parts. They were furnished mainly by the Pawling & Harnischfeger Company and the Cleveland Crane Company.

Much of the riveting (of sheets particularly) is done by compressed air, and this power is also made use of in finishing most of the car parts. A sand blasting apparatus for cleaning the sheets and other parts of car, preparatory to painting, has been installed and is also operated by compressed air. A complete electric light plant furnishes light for the shops as well as for the office building some little distance away.

The operation of the main shop is from east to west. The hydraulic presses are located in the east end where the bolster and car parts are shaped and punched. The car and bolster riveting departments are in the west end of the shop. The castings are brought from the storehouse, south of the main shop, into the center of the shop where they are riveted to the steel bolster and car parts. The body and truck bolsters, steel underframes and all-steel cars are assembled, painted and shipped from the west end.

Immediately south of the main shop is the power house, 80 x 220 feet in size, part of which until recently was utilized as a machine shop. The six horizontal boilers, with an aggregate capacity of about 1,000 h.p., are in the west end of the building, and the engine room adjoining contains the pumps and machinery.

Still further to the south and east are the extensive store houses for the material, covering an area of several acres, and to the west is the paint shop and other minor buildings in a group by themselves. The D. R. I. & N. W. Ry., C. M. & St. P. Ry. and the C. B. & Q. Ry. run through the manufacturing tract, and excellent switching and yard facilities, including four tracks, running through the main buildings, have been obtained. Locomotive cranes facilitate the loading and unloading of materials in the yards and shops.

The machine shop, as has been stated, was until recently located in the power building, but the available space proving entirely inadequate for the purpose, it was last fall decided to erect a new machine shop directly east of the power house and south of the main shops. The new machine shop is a building 50 x 380 feet in size, of which the west 80 feet will be utilized for the blacksmith shop, leaving the size of the machine shop proper 50 x 300 feet.

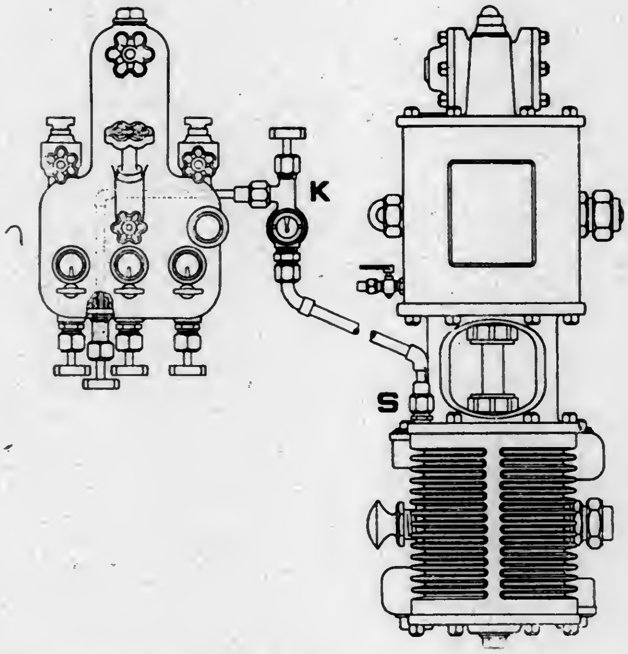
The office building of the company has also recently been enlarged by the addition of a second story, which will give more room for the clerical force.

To give an idea of the progress made by the Bettendorf company in the manufacture of railway equipment, it may be stated that starting in about ten years ago with the production of the I-beam bolsters in the old Davenport plant, there has since been added the manufacture of the Bettendorf steel car underframe, the cast steel truck with integral journal boxes, and finally complete tank and freight cars. The capacity of the present plant is 25 complete cars or forty steel underframes in a day.

SIGHT FEED AIR CYLINDER LUBRICATOR.

For the purpose of securing proper lubrication of the air cylinders of locomotive air pumps the Detroit Lubricator Company has designed a sight feed lubricator attachment which gives the engineer complete and convenient control of the lubrication of his pump. It consists of three parts: first, the emergency valve, which takes the place of the plug in the bottom of a Detroit lubricator. Next comes the sight feed fitting, which is equipped with regular bull's-eye glasses and can be located at any convenient point in the boiler head within reach of the engineer. The third fitting is a check valve connection, which takes the place of the present oil cup on the air cylinder and is provided with a ball check seating upwards, and prevents the compressed air from entering the oil delivery pipe. The illustration shows the arrangement and connections for these fittings.

The location of the sight feed fitting should be such as to give a gradual incline to the pipe leading to the check valve, so that the oil can flow by gravity to the pump. There must, however,



be a trap between the lubricator and sight feed fitting to prevent the water from entering the supply pipe after all the oil has been fed from the reservoir. To provide for this the oil supply pipe is extended upward from the emergency valve to about the same height as the upper part of the oil reservoir.

Provision is made for a double sight feed fitting for use with compound or duplex pumps. The makers of this device do not advise a constant feed of oil to the cylinders, but recommend that not more than ten drops of oil be fed at any one time and these at intervals, according to the judgment of the engineer.

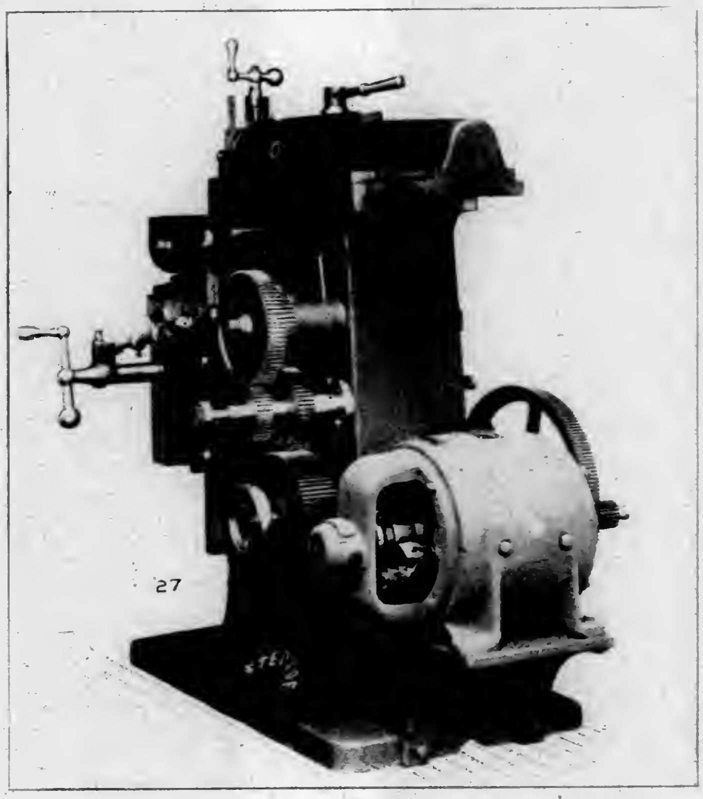
900,000 Patents.—The nine hundred thousandth patent from the United States Patent Office was issued September 29. It was granted too Charles D. Seeberger, of Yonkers, N. Y., and refers to an improvement on traveling stairs, such as are used in hotels and other large buildings. Mr. Moore estimates that the one millionth patent will be reached in the year 1911. The total of patents issued by the United States is not very far below the total for all other countries for all time.

"The Density of Traffic is, of course, the paramount feature as to the savings to be effected by electrification. It is not to be forgotten that, in electrifying, interest, depreciation, insurance and taxes follow closely on the heels of the capital investment in equipment and material necessary to electric operation. The heavier the traffic, the greater will be the economies derived from the two above mentioned sources."—*W. S. Murray, N. Y., N. H. & H. R. R.*

14-INCH CRANK SHAPER.

A crank-shaper, which in mechanical construction differs from anything now on the market, has recently been brought out by the John Steptoe Shaper Company, of Cincinnati. This machine was built especially to economize on space, the original design being for use on a revenue cutter in government service, where the available room was exceedingly small. Reference to the illustration will show that the motor does not take up any extra room at all, being arranged to set on the base of the machine against the column, where it does not require any greater clearance than does the return stroke of the ram.

This is a 14 in. single geared machine driven by a 2½ h.p. motor. The pinion on the motor shaft is rawhide with brass flanges, being 2 in. in diameter and having 22 teeth. It meshes with the large gear 16 in. in diameter, with 100 teeth, giving a



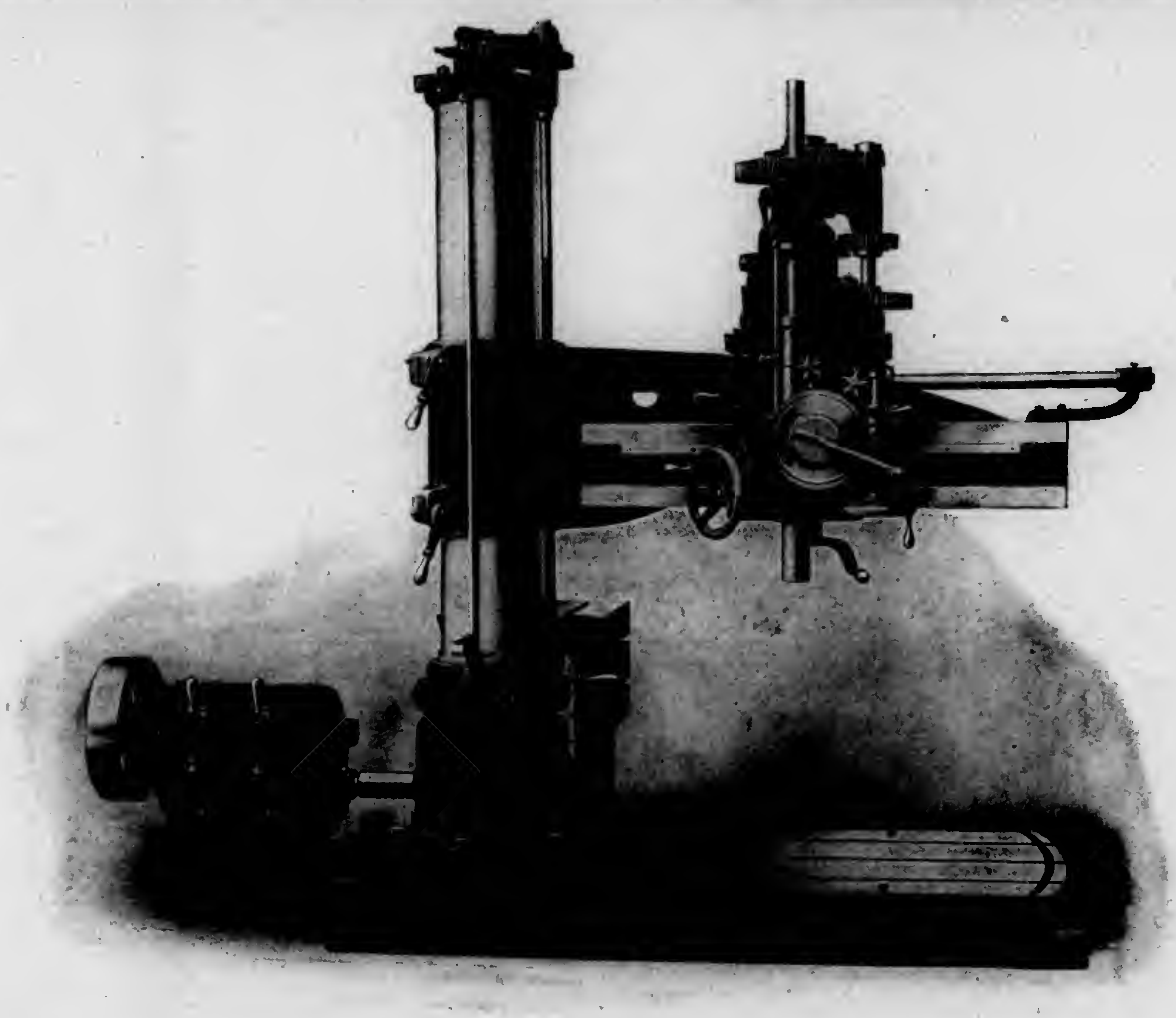
14-INCH CRANK SHAPER.

gear ratio of about 8 to 1. The shaft for the 16 in. gear has a 5 in. bearing on both sides of the column and carries at the opposite end the wide gear shown at the bottom of the train of gears in the illustration. This wide-faced gear is used in order to provide for the shifting of the compound gear arranged just above it. The compound gear contains a 6 and a 4 in. diameter wheel arranged on the same shaft so that when one is in mesh the other is thrown out. The hand wheel at the bottom is used to turn the gears sufficiently to make the compound gear mesh when it is shifted to change the speed.

The illustration shows the machine with the gear covers removed.

Mexican Railroads.—In a message to the Mexican Congress President Diaz says that 265 miles of new railroad have been built in Mexico in the last six months, and that on September 1 there was a total of 14,665 miles of railroad in the country. Practically all the new mileage is that of the Cananea, Yaqui River & Pacific Ry., which E. H. Harriman and his associates are building down the Pacific slope.

Chinese Railroads.—Since the war with Japan the mileage of the Chinese railroads has materially increased. Including the Manchurian railroads there are now 3,200 miles of road in operation, an equal amount projected and 1,100 miles building.



FOUR-FOOT TRIPLE GEARED RADIAL DRILL.

TRIPLE GEARED HIGH SPEED RADIAL DRILL.

The introduction of high speed twist drills, particularly those of the Celfor pattern, has opened up a new field for extremely rapid drilling and has made it necessary to design drilling machines capable of pushing the twist drills to their full capacity. For this purpose the American Tool Works Company, Cincinnati, O., has brought out a full new line of radial drills, the 4-foot size of which is shown in the accompanying illustration These drills have surpassed all previous records for rapid drilling and heavy tapping, as is shown by the accompanying tests.

The 4-foot drill has a capacity for drilling to the center of an 8 ft. 1½ in. circle; has a clearance of 4 ft. 10½ in. between the spindle and the base; a 15 in. traverse of the spindle and a 3 ft. 4¼ in. traverse of the head on the arm.

The feeding mechanism on the head provides eight different rates of feed, which are all readily obtained by the simple turning of the dial on the feed box until the desired feed, indexed thereon, comes opposite a fixed pointer. The feed mechanism is of the all-gear type and is operated through a friction which will transmit more power without slipping than the drill or tap will stand. It thus forms practically a positive clutch, as far as the power is concerned, but still protects the feed gears.

The spindle has 24 changes of speed, ranging from 18 to 356 r. p. m., all available without stopping the machine. The speed box, of the geared friction type, provides four changes of speed and is so arranged that there is no shock to the parts when throwing in any speed.

By rounding the edges of the teeth of the gears in the triple gear mechanism and by a special feature, which is not given publicity, the gears may be thrown in at high speed with no shock to the parts, which makes the machine practically fool proof and facilitates rapid production. A tapping mechanism is carried on the head between the triple gears and the speed box, thus giving to the friction the benefit of the triple gear ratios, and making unusually heavy tapping operations possible. It also permits the taps being backed out at an accelerated speed.

The design of the machine structure is most substantial in every way, the column being of the double tubular type with a

Drilling and Tapping Tests.

DRILLING TEST IN STEEL 1" THICK.

Size Drill	Speeds Revol's	Speeds Cutting Speed	Feeds Per Revol'n	Feeds Inches Per Min.	Back Gears Ratio	Back Gears Position	Actual H. P.	Amp.	Volts.
9/16" H. S.	356	52.3′	.012	4.27	1.48	Top	4.2	14	224.
3/4" H. S.	313	61.5′	.012	3.75	1.48	"	10.8	36	"
1 1/32" H. S.	188	50.9′	.024	4.51	1.48	"	9.0	30	"
1 5/32" H. S.	188	56.9′	.024	4.51	1.48	"	9.3	31	"
1 23/32" H. S.	128	57.6′	.024	3.07	4.22	Middle	8.4	28	"
1 31/32" H. S.	167	86.2′	.012	2.00	1.48	Top	7.8	26	"

DRILLING TEST IN CAST IRON 2" THICK.

Size Drill	Speeds Revol's	Speeds Cutting Speed	Feeds Per Revol'n	Feeds Inches Per Min.	Back Gears Ratio	Back Gears Position	Actual H. P.	Amp.	Volts.
1/2" C.....	356	46.6′	.046	16.3	1.48	Top	5.75	19	226.
1" C.......	216	56.6′	.046	9.9	1.48	"	5.45	18	"
1 1/32" H. S.	313	84.5′	.046	14.4	1.48	"	13.2	44	224.
1 7/32" H. S.	313	99.8′	.046	14.4	1.48	"	15.3	51	"
1 15/32" H. S.	216	83.1′	.033	7.1	1.48	"	12.6	42	"
1 23/32" H. S.	216	97.0′	.033	7.1	1.48	"	16.8	56	"
1 31/32" H. S.	128	66.0′	.033	4.2	4.22	Middle	15.6	52	"
3½" H. S.	60	55.0′	.024	1.4	4.22	"	10.2	34	226.

TAPPING TEST WITH PIPE TAPS IN CAST IRON 2" THICK.

Diam. Tap	Speeds Revol's	Speeds Cutting Speed	Feeds Per Revol'n	Feeds Inches Per Min.	Back Gears Ratio	Back Gears Position	Actual H. P.	Amp.	Volts.
4"...........	18	21.2′	⅛"	2¼"	12.02	Bottom	6.6	22.	225.
5"...........	18	26.2′	⅛"	2¼"	12.02	"	7.7	26.	222.
6"...........	18	30.8′	⅛"	2¼"	12.02	"	9.0	30.	224.

patent clamping ring, which offers exceptional rigidity, the arm also being most carefully designed to give the greatest resistance to bending and torsional strains. The control of the mechanism for moving the head, arm, spindle, etc., is arranged at the most convenient points and the closest attention has been given throughout to time and labor-saving arrangements.

TWO VALUABLE NEW TOOLS.

A great deal is heard about the efficiency of the workmen and of machine tools, but comparatively little is said about the small tools around the shop, which, as a matter of fact, are the controlling feature of the efficiency of a good proportion of railroad shop men. The design, construction and condition of small tools in a shop require as close attention as do many seemingly more important features if the best results are to be obtained. This attention has been given in some shops with surprising results, and the tool makers are ably co-operating and have on their staffs some of the best mechanical talent in the country which is giving its whole attention to the improvement of small tools, with excellent results.

DOUBLE TANG DRILL SOCKET.

HIGH SPEED STEEL REAMER.

Among the most recent products of this kind are two tools being placed on the market by the Cleveland Twist Drill Co., Cleveland, O. One of these is a simple, but practical, socket for doing away with taper shank tang troubles. The other is a reamer which has high speed steel blades solidly joined to a body of special soft steel, which, while giving the advantage of the high speed steel cutters, can be sold at a price considerably below that of reamers constructed of this material throughout. These tools are shown in the accompanying illustration.

The double tang socket instead of having one slot like the ordinary socket has two, one above the other, the upper slot taking the regular tang of the drill, or reamer, and the lower one receiving a secondary tang. This secondary tang is considerably thicker than the regular tang and practically cannot be twisted off. It can be ground on the shank in a few minutes and in cases where the regular tang has been broken it permits the tool to continue in service with even a stronger drive than when new. This socket will fit any spindle having a regular taper hole and can be removed with the ordinary drift, a small piece of bar steel being inserted to compensate for the regular tang when it has been broken off. These sockets are listed at the same price as the regular sockets.

The "Peerless" high speed steel reamers have all the hardness and cutting qualities of the solid high speed steel tools, and at the same time are less brittle. The blades alone are hardened and are then fitted and solidly joined into a special soft steel body by a process which has been developed and patented by the

HIGH SPEED STEEL EXPANDING REAMER.

makers. This unites the steel blades with the body into one solid inseparable reamer.

Another form of Peerless reamers is also shown in the illustration in the shape of an expansion reamer, which are said to be the only reamer of this type that has the full number of cutting edges of the solid tool. It is also claimed that they will give considerably more expansion than carbon steel reamers of a similar design.

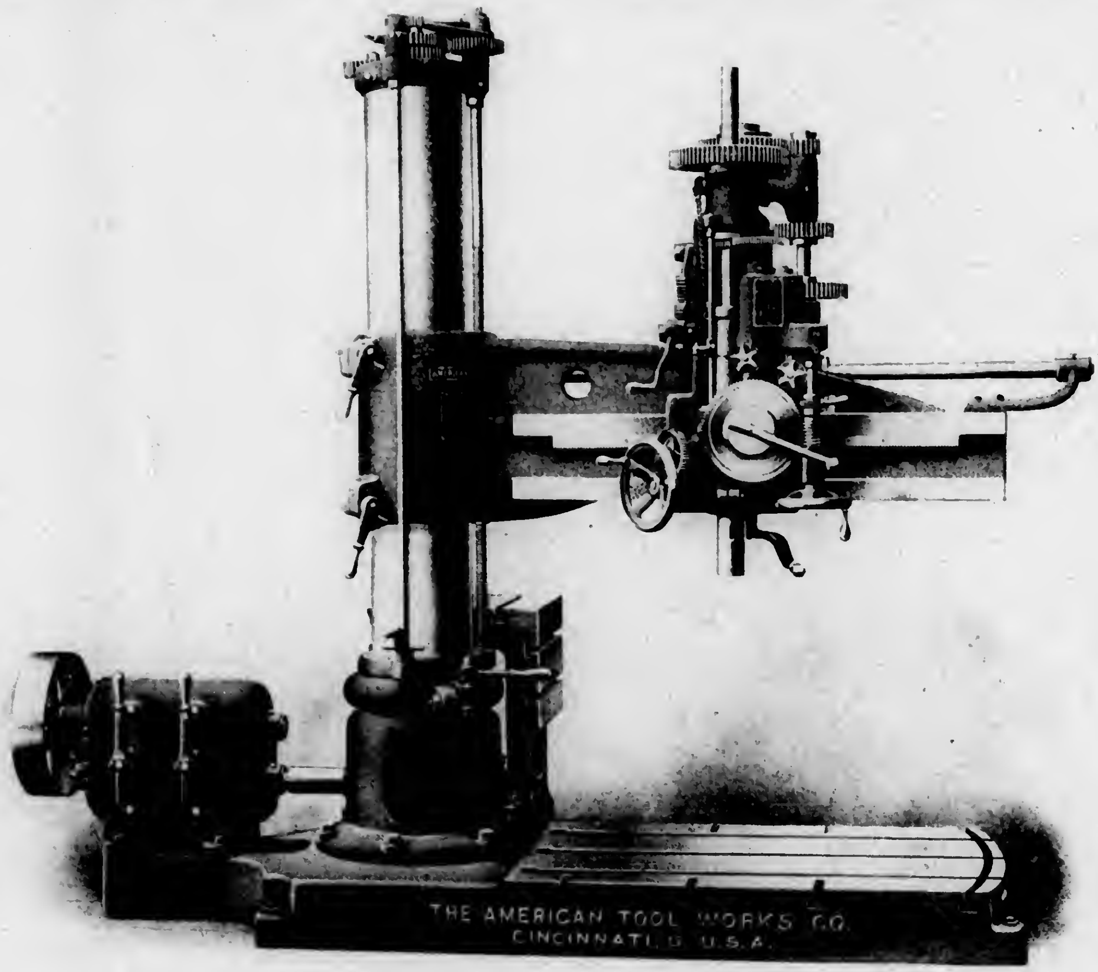
COMPACT ELECTRIC CRANE TROLLEY.

The application of electricity to traveling cranes has permitted the rapid and accurate handling of enormous weights, which has had so great a bearing on the largely increased output and efficiency of modern machine shops. The application of electric motors at this point has recently been given careful study by the electrical shop experts and consequent improvement with a large reduction in weight and size for an increased capacity has been made. The accompanying illustration shows an example of this in the shape of a five-ton trolley for a traveling crane, which is equipped with Crocker-Wheeler motors. The hoist motor is a seven h.p. machine of the box type and the rack motor 1½ h.p. of the circular type. Both of these motors, as can be seen, are very compact, taking up practically no room on

FIVE-TON TROLLEY FOR TRAVELING CRANE.

the crane and permit a very light construction throughout. They are both, however, easily accessible. A feature of this trolley is a mechanical brake, which operates in a submerged oil bath. The crane was built by the Cleveland Crane and Car Company, of Wickliffe, Ohio.

RELATIVE USE OF STEAM, WATER POWER, ETC.—Of the total estimated power at present produced by prime movers in the United States about 26,000,000 h.p. is produced by steam engines, 3,000,000 h.p. by water motors, and 800,000 h.p. by gas and oil engines. These figures emphasize the present position of the steam engine in our industrial development and the relatively much less important place now occupied by water power.—*H. St. Clair Putnam at the Conference on Natural Resources.*



FOUR FOOT TRIPLE GEARED RADIAL DRILL.

TRIPLE GEARED HIGH SPEED RADIAL DRILL.

The introduction of high speed twist drills, particularly those of the Celfor pattern, has opened up a new field for extremely rapid drilling and has made it necessary to design drilling machines capable of pushing the twist drills to their full capacity. For this purpose the American Tool Works Company, Cincinnati, O., has brought out a full new line of radial drills, the 4 foot size of which is shown in the accompanying illustration. These drills have surpassed all previous records for rapid drilling and heavy tapping, as is shown by the accompanying tests.

The 4 foot drill has a capacity for drilling to the center of an 8 ft. [illegible] circle; has a clearance of 4 ft. 10½ in. between the spindle and the base; a 15 in. traverse of the spindle and a 3 ft. [illegible] in. traverse of the head on the arm.

The feeding mechanism on the head provides eight different rates of feed, which are all readily obtained by the simple turning of the dial on the feed box, until the desired feed, indexed thereon, comes opposite a fixed pointer. The feed mechanism is of the all gear type and is operated through a friction which will transmit more power without slipping than the drill or tap will stand. It thus forms practically a positive clutch, as far as the power is concerned, but still protects the feed gears.

The spindle has 24 changes of speed, ranging from 18 to 350 r. p. m., all available without stopping the machine. The speed box, of the geared friction type, provides four changes of speed and is so arranged that there is no shock to the parts when throwing in any speed.

By rounding the edges of the teeth of the gears in the triple gear mechanism and by a special feature, which is not given publicity, the gears may be thrown in at high speed with no shock to the parts, which makes the machine practically fool proof and facilitates rapid production. A tapping mechanism is carried on the head between the triple gears and the speed box, thus giving to the friction the benefit of the triple gear ratios, and making unusually heavy tapping operations possible. It also permits the taps being backed out at an accelerated speed.

The design of the machine structure is most substantial in every way, the column being of the double tubular type with a

DRILLING AND TAPPING TESTS.

DRILLING TEST IN STEEL [illegible] THICK.

Size	Drill	Speeds Revol's	Speeds Cutting Speed	Feeds Per Revol'n	Feeds Inches Per Min.	Back Gears Ratio	Back Gears Position	Actual H. P.	Amp.	Volts
[illegible]	H. S	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Top	4.2	14	221
[illegible]	H. S	[illegible]	[illegible]	[illegible]	[illegible]	1.48	[illegible]	10.8	[illegible]	[illegible]
[illegible]	H. S.	[illegible]	[illegible]	[illegible]	[illegible]	1.48	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	H. S	188	[illegible]	[illegible]	[illegible]	1.48	"	[illegible]	[illegible]	"
[illegible]	H. S	128	[illegible]	.021	[illegible]	4.22	Middle	8.4	28	"
[illegible]	H. S	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Top	[illegible]	26	"

DRILLING TEST IN CAST IRON 2" THICK.

Size	Drill	Speeds Revol's	Speeds Cutting Speed	Feeds Per Revol'n	Feeds Inches Per Min.	Back Gears Ratio	Back Gears Position	Actual H. P.	Amp.	Volts
[illegible]	C	[illegible]	[illegible]	.016	16	1.48	Top	5.75	19	226.
[illegible]	C	216	[illegible]	.046	9.9	1.48	"	5.45	18	"
1½	H. S	[illegible]	81.5	.046	14.4	1.48	"	13.2	44	221
[illegible]	H. S	[illegible]	[illegible]	.046	14.4	1.48	"	15.3	51	"
[illegible]	H. S	216	[illegible]	.033	7.1	1.48	"	12.6	42	"
[illegible]	H. S	216	97.0	.033	7.1	1.48	"	16.8	56	"
[illegible]	H. S	128	66.0	.033	4.2	4.22	Middle	15.6	52	"
[illegible]	H. S	[illegible]	55.0	.021	1.4	4.22	"	10.2	34	226.

TAPPING TEST WITH PIPE TAPS IN CAST IRON 2" THICK.

Diam. Tap	Speeds Revol's	Speeds Cutting Speed	Feeds Per Revol'n	Feeds Inches Per Min.	Back Gears Ratio	Back Gears Position	Actual H. P.	Amp.	Volts
4	18	21.2'	1/8"	2¼"	12.02	Bottom	6.6	22.	225
5	18	26.2'	1/8"	2¼"	12.02	"	7.7	26.	222
[illegible]	18	30.8'	1/8"	2¼"	12.02	"	9.0	30.	224

patent clamping ring, which offers exceptional rigidity, the arm also being most carefully designed to give the greatest resistance to bending and torsional strains. The control of the mechanism for moving the head, arm, spindle, etc., is arranged at the most convenient points and the closest attention has been given throughout to time and labor saving arrangements.

TWO VALUABLE NEW TOOLS.

A great deal is heard about the efficiency of the workmen and of machine tools, but comparatively little is said about the small tools around the shop, which, as a matter of fact, are the controlling feature of the efficiency of a good proportion of railroad shop men. The design, construction and condition of small tools in a shop require as close attention as do many seemingly more important features if the best results are to be obtained. This attention has been given in some shops with surprising results, and the tool makers are ably co-operating and have on their staffs some of the best mechanical talent in the country which is giving its whole attention to the improvement of small tools, with excellent results.

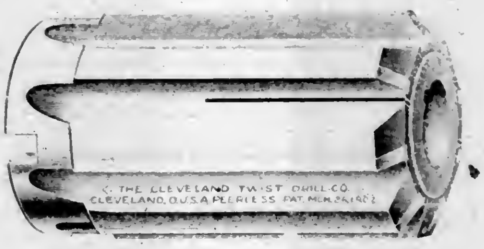
DOUBLE TANG DRILL SOCKET.

HIGH SPEED STEEL REAMER.

Among the most recent products of this kind are two tools being placed on the market by the Cleveland Twist Drill Co., Cleveland, O. One of these is a simple, but practical, socket for doing away with taper shank tang troubles. The other is a reamer which has high speed steel blades solidly joined to a body of special soft steel, which, while giving the advantage of the high speed steel cutters, can be sold at a price considerably below that of reamers constructed of this material throughout. These tools are shown in the accompanying illustration.

The double tang socket instead of having one slot like the ordinary socket has two, one above the other, the upper slot taking the regular tang of the drill, or reamer, and the lower one receiving a secondary tang. This secondary tang is considerably thicker than the regular tang and practically cannot be twisted off. It can be ground on the shank in a few minutes and in cases where the regular tang has been broken it permits the tool to continue in service with even a stronger drive than when new. This socket will fit any spindle having a regular taper hole and can be removed with the ordinary drift, a small piece of bar steel being inserted to compensate for the regular tang when it has been broken off. These sockets are listed at the same price as the regular sockets.

The "Peerless" high speed steel reamers have all the hardness and cutting qualities of the solid high speed steel tools, and at the same time are less brittle. The blades alone are hardened and are then fitted and solidly joined into a special soft steel body by a process which has been developed and patented by the



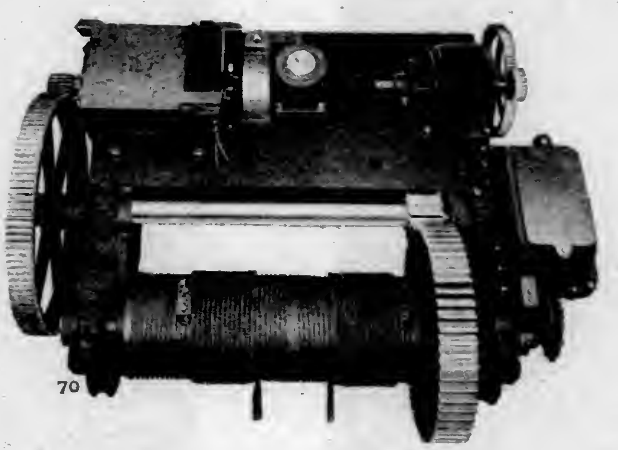
HIGH SPEED STEEL EXPANDING REAMER.

makers. This unites the steel blades with the body into one solid inseparable reamer.

Another form of Peerless reamers is also shown in the illustration in the shape of an expansion reamer, which are said to be the only reamer of this type that has the full number of cutting edges of the solid tool. It is also claimed that they will give considerably more expansion than carbon steel reamers of a similar design.

COMPACT ELECTRIC CRANE TROLLEY.

The application of electricity to traveling cranes has permitted the rapid and accurate handling of enormous weights, which has had so great a bearing on the largely increased output and efficiency of modern machine shops. The application of electric motors at this point has recently been given careful study by the electrical shop experts and consequent improvement with a large reduction in weight and size for an increased capacity has been made. The accompanying illustration shows an example of this in the shape of a five-ton trolley for a traveling crane, which is equipped with Crocker Wheeler motors. The hoist motor is a seven h.p. machine of the box type and the rack motor 1½ h.p. of the circular type. Both of these motors, as can be seen, are very compact, taking up practically no room on



FIVE-TON TROLLEY FOR TRAVELING CRANE.

the crane and permit a very light construction throughout. They are both, however, easily accessible. A feature of this trolley is a mechanical brake, which operates in a submerged oil bath. The crane was built by the Cleveland Crane and Car Company, of Wickliffe, Ohio.

RELATIVE USE OF STEAM, WATER POWER, ETC.—Of the total estimated power at present produced by prime movers in the United States about 26,000,000 h.p. is produced by steam engines, 3,000,000 h.p. by water motors, and 800,000 h.p. by gas and oil engines. These figures emphasize the present position of the steam engine in our industrial development and the relatively much less important place now occupied by water power.—*H. St. Clair Putnam at the Conference on Natural Resources.*

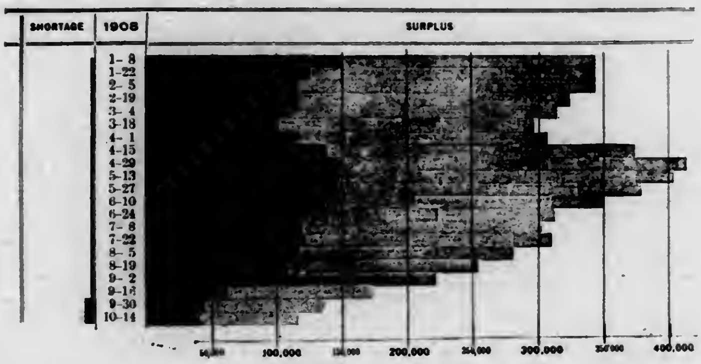
EXTENT OF PINTSCH GAS LIGHTING.

The following table shows the total number of cars and locomotives equipped with Pintsch Lighting System throughout the world, on April 1, 1908, and also the large increase during the past 4½ years:

Railroads in	October 1, 1903		April 1, 1908	
	Cars	Locomotives	Cars	Locomotives
Germany	42,471	5,583	52,846	7,958
Denmark	45	....	45	....
England	19,256	....	20,459	....
France	6,837	....	11,914	....
Holland	3,663	5	3,978	5
Italy	1,537	....	1,552	....
Switzerland	392	2	398	2
Portugal	67	....	67	....
Spain	38	....	38	....
Austria	5,003	....	6,465	....
Russia	3,467	132	4,428	329
Sweden	731	53	944	67
Servia	216	....	219	....
Bulgaria	98	....	154	....
Turkey	114	....	119	....
Egypt	148	....	382	....
United States	21,380	....	32,455	....
Canada	393	....		....
Brazil	978	31	1,324	31
Argentine	1,133	....	1,548	127
Chile	46	....	46	....
India	10,312	....	13,686	60
Australia	2,396	....	2,945	....
Japan	150	....	180	....
Total	120,871	5,806	156,172	8,579
Increase in 4½ years			35,301	2,773
Average increase per annum			7,845	616
Total average equipments per annum				8,461

FREIGHT CAR SITUATION.

Statistical Report No. 33, issued by the Committee on Car Efficiency of the American Railway Association, shows a total of 115,036 surplus cars on October 14, 1908, this being a decrease of 18,756 since the previous fortnightly report. It also shows a



slight shortage of both box and other types of cars reported from the Canadian & Pacific groups. The accompanying chart shows graphically the car shortage since January 8, 1908, the black portion representing the box cars and the shaded portion other types of cars.

BOOKS.

Foundry Work. By William C. Stimpson. Cloth. 145 pages. 6½ x 9½. Illustrated. Published by the American School of Correspondence, Chicago, Ill. Price, $1.00.

This forms one of a series of practical and scientific books for home study, being prepared by the American School of Correspondence, others of which we have mentioned in previous issues. The keynote of all these works is practicability. The present book is divided into three parts, the first treating on materials and the method of molding, in which all molders' tools and appliances are illustrated and their use described. The second part is on the making and finishing of castings and describes cupolas, furnaces, pressure blowers and other furnace appliances, proper method of pouring and a discussion of foundry work in all different metals and alloys. The third chapter is on shop management and contains a large number of useful tables, such as pressure in molds for different depths, proper temperature for molding different materials, specific gravities, etc.

Elements of Railroad Track and Construction. By Winter L. Wilson. 313 pages. 5 x 7½. Illustrated. Bound in cloth. Published by John Wiley & Sons, 43 E. 19th street, New York. Price, $2.00.

As the title indicates, the author of this book has not attempted to treat the subject in great detail, but has very successfully presented the fundamental principles, which will permit the reader to form an excellent general idea of the subject. The book has been prepared principally for class room work and with the idea that details of practice are much better and more easily learned by actual experience. Line drawings and photographs are used profusely in connection with the definitions and problems. In spite of the briefness of the work the subject has been covered in a surprisingly complete manner, there being practically no sub-division which is not considered in some respect.

Lighting Country Homes by Private Electric Plants. By T. H. Amrine. Bulletin No. 25 of the Engineering Experiment Station of the University of Illinois. Copies may be obtained gratis upon application to the Director, Engineering Experiment Station, Urbana, Illinois.

This bulletin calls attention to the fact that the present state of development of the storage battery and the recent production of the efficient tungsten filament incandescent lamp have opened up new possibilities in the way of country home lighting by private electric plants. The paper includes some explanations concerning artificial illumination, the selection of lighting fixtures and the planning of a house lighting system, the design and estimate of the cost of a small private plant, suggestions about ordering apparatus and instructions for its operation and care. The bulletin is intended for the non-technical reader and an attempt has been made to show the steps in the design in such a clear and simple manner that any person could decide upon the equipment needed and order it intelligently.

Cement Laboratory Manual. By L. A. Waterbury. Bound in cloth. 122 pages. 5 x 7½. Illustrated. Published by John Wiley & Sons, 43 East 19th street, New York. Price, $1.00.

The proper methods of procedure in testing Portland cements have an important influence upon the value of the results and the various associations interested in questions of this kind have devoted a large amount of time to preparing standards for making tests, without which, of course, comparisons or published results are comparatively worthless. While this book has been prepared for the use of students taking a course in cement laboratory practice at the University of Illinois, the information contained therein is of equal value to workers in any cement testing laboratory. It is, of course, more or less elementary and the first two chapters are devoted to instruction in the care of apparatus, general behavior in and about the laboratory and a complete illustrated description of all the apparatus to be used. The third chapter details the procedure in making various tests, which are illustrated by fourteen problems. Three appendixes give the reports of committees of the American Society of Civil Engineers, American Society for Testing Materials and the Society of Chemical Industry on this subject.

The Modification of Illinois Coal by Low Temperature Distillation. By S. W. Parr and C. K. Francis. Bulletin No. 24 of the Engineering Experiment Station of the University of Illinois. Copies may be obtained gratis upon application to the Director, Engineering Experiment Station, Urbana, Illinois.

This bulletin describes an attempt to remove from bituminous coals the heavy hydro-carbons and to produce a fuel essentially

smokeless. The original impetus to the experiments was given by the anthracite strike of 1902, efforts then being made to produce artificially, from Illinois coals, material which would be sufficiently anthracitic in character to supply the demand for that type of fuel. Certain unexpected results were obtained in connection with the temperatures at which the oxidation of coal may be effected, and a large part of this work, therefore, is a description of this phase of the subject. The striking interest in these experiments resides in the fact that the temperatures for rapid oxidation, especially with finely divided coal, are sufficiently low to bring this material within the range of conditions which are frequently met in storage. These results, therefore, have a direct bearing upon the weathering of coal, its spontaneous combustion, and probably, also, to a certain extent, upon the problems involved in mine explosions.

Concerning the production of a smokeless fuel from bituminous coals, high in volatile matter, the results are as yet incomplete. At a temperature not exceeding 400° Centigrade, a sufficient amount of hydro-carbons may be driven off to leave a substance closely resembling in composition the coals of the Pocahontas type. This material is exceedingly friable, and would need to be subjected to a process of briquetting. It has some of the characteristics of coke, but burns readily, and is especially well adapted for domestic use, being clean and smokeless. The commercial possibilities for the production of a smokeless fuel of this type have not been taken up, since the present work deals only with the scientific principles involved.

PERSONALS.

T. L. Smith, master mechanic of the Chicago, Burlington & Quincy Ry., at Beardstown, Ill., died September 29.

C. W. Tessiers has been appointed master car builder of the Mexican Central R. R., succeeding J. H. O'Brien, resigned.

W. M. Daze has been appointed to succeed Mr. George as master mechanic of the Santa Fé, with office at Winslow, Ariz.

John Mooney has been appointed assistant superintendent of motive power of the Grand Trunk Pacific, with office at Rivers, Man.

E. M. Sweetman has been appointed master mechanic of the Southern Railway at Sheffield, Ala., succeeding W. F. Moran, resigned.

A. T. Shortt has been appointed master mechanic of the Canadian Pacific Ry., at Cranbrook, B. C., succeeding A. N. Hobkirk, promoted.

R. F. Kilpatrick has been appointed assistant superintendent of motive power of the Denver & Rio Grande Ry., with office at Burnham, Colo.

Frank W. Taylor, general foreman of the Illinois Central, at Louisville, Ky., has been appointed master mechanic of the Peoria division, at Mattoon, Ill.

S. E. Kildoyle has been appointed master mechanic and master car builder of the Vera Cruz & Isthmus Ry., with headquarters at Sierra Blanco, V. C., Mex.

J. F. Casey has been appointed general foreman, car department, of the St. Louis, Brownsville & Mexico Ry., with headquarters at Kingsville, Texas.

A. H. Powell, master mechanic of the Denver & Rio Grande R. R., at Grand Junction, Colo., has been appointed master mechanic at Salt Lake City, Utah.

C. H. Osborn, master mechanic of the Chicago & Northwestern Ry., at Baraboo, Wis., has been appointed assistant superintendent of the car department, with office at Chicago.

A. J. McKillop, master mechanic of the Illinois Central R. R. at Freeport, Ill., has been appointed master mechanic of the Chicago division, succeeding T. F. Barton, resigned.

John Schrader, night car foreman of the New York Central & Hudson River R. R., has been appointed general foreman of the car department, Mott Haven yards, New York.

G. M. Crownover, assistant master mechanic of the Chicago division of the Illinois Central R. R., has been put in charge of the Burnside shops, and the former position has been abolished.

J. T. Carroll, assistant master mechanic of the Lake Shore & Michigan Southern Ry., at Elkhart, Ind., has been appointed master mechanic of the Lake Erie & Western Ry., at Tipton, Ky.

W. J. Hoskin, master mechanic of the Chicago Great Western Ry., at Des Moines, Iowa, has been appointed master mechanic of the Chicago & Alton R. R., with headquarters at Bloomington, Ill.

R. R. Royal has been appointed foreman in the locomotive and car department of the Mobile, Jackson & Kansas City Ry., at Louisville, Ky., succeeding G. W. Brewer, assigned to other duties.

C. C. Reynolds has been appointed road foreman of engines of the Santa Fé (Coast Lines) at Winslow, Ariz., with jurisdiction over the Albuquerque division, succeeding William Daze, promoted.

A. R. Ayres, assistant superintendent of shops of the Lake Shore and Michigan Southern Ry., at Collinwood, Ohio, has been appointed to succeed Mr. Carroll, as assistant master mechanic at Elkhart, Ind.

T. F. Barton, master mechanic of the Chicago division of the Illinois Central R. R., has been appointed master mechanic of the Morris and Essex division of the Delaware, Lackawanna & Western R. R.

V. U. Powell, master mechanic of the Peoria division of the Illinois Central R. R., and the Indianapolis Southern Ry., at Mattoon, Ill., succeeds Mr. McKillop as master mechanic, at Freeport, Ill.

M. S. Curley has been appointed master mechanic of the Beaumont, Sour Lake & Western, the Colorado Southern, New Orleans & Pacific and the Orange & Northwestern at Beaumont, Tex., succeeding A. L. Moler, resigned.

W. A. George, master mechanic of the second and third divisions, has been appointed to succeed Mr. Harlow as master mechanic of the first district of the Albuquerque division of the Santa Fé, with office at Albuquerque, N. Mex.

E. H. Harlow, master mechanic of the first district of the Albuquerque division of the Santa Fé (Coast Lines), has been appointed master mechanic of the Valley division, with office at Richmond, Cal., succeeding A. B. Todd, resigned.

F. W. Thomas, supervisor of apprentices of the Santa Fé, has been appointed also engineer of tests, succeeding T. E. Layden, assigned to other duties. All matters pertaining to tests should be addressed to Mr. Thomas as engineer of tests, and all matters pertaining to apprentices should be addressed to him as supervisor of apprentices.

CATALOGS

IN WRITING FOR THESE PLEASE MENTION THIS JOURNAL.

FLEXIBLE STAYBOLTS.—The Flannery Bolt Company, 328 Frick Building, Pittsburgh, Pa., are sending out a flyer calling attention to the success the Tate flexible staybolt has had during the past four years. A list of the representatives of the company is given.

LOGARITHMETIC CROSS SECTION PAPER.—A circular, which comprises a sample, on the back of which is illustrated the method of using and the value in many computations of the Jensen logarithmetic paper, is being sent out by J. Norman Jensen, 797 N. Leavitt street, Chicago.

HIGH SPEED DRILLS.—Catalog No. 4 from the Hackett High Speed Drill Company, 90 West street, New York City, contains a description of the Hackett high speed drill and gives price lists of the various sizes.

CRANES FOR RAILROAD SERVICE.—The Whiting Foundry Equipment Company, Harvey, Ill., is issuing a booklet which illustrates cranes of practically all types that have been installed by this company in various railroad machine, erecting and boiler shops, as well as transfer tables and cranes for outdoor service. The illustrations include electric, pneumatic, and hand types in all capacities.

CONVEYING MACHINERY.—The Jeffrey Manufacturing Company, Columbus, O., is issuing a number of bulletins and catalogs illustrating and describing the conveyor belt and other types of conveyors for practically any commodity and under any conceivable circumstance. The illustrations show most of this apparatus in actual service and cause surprise at the widespread adaptability of this method of labor saving. Other bulletins are issued by the same company on the subjects of coal washing plants and equipments and coal tipples and shaking screens.

PLANERS.—The Cincinnati Planer Company, Cincinnati, O., is issuing catalog No. 10, which most attractively illustrates and describes the imposing array of various types of planers manufactured by it. The details of construction are very carefully illustrated and described. Several machines are shown which have a variable speed device, consisting of a speed box mounted on top of the housing. This provides for six different cutting speeds with the same return speed. There is nothing in the planer line that is not manufactured by this company.

CONSOLIDATED SUPPLY COMPANY.—Catalog No. 15 being issued by the above company, whose office is in the Manhattan Building, 321 Dearborn street, Chicago, is of the loose leaf form and binds together a number of bulletins on the large variety of railway supplies handled by this company. Among these might be mentioned the Consolidated patented metal car roof, an example of which is shown by a photograph as still in excellent condition after five years' service. This type of car roof is just being put on general sale. This company handles the Monarch couplers for locomotives and cars and are agents for the Reading multiple gear chain hoists and the Northern fire extinguisher. They are also manufacturers' agents for a large variety of railway supplies, mentioned in this catalog.

BRILL'S MAGAZINE.—The October 15th issue of *Brill's Magazine* contains an excellent illustrated description of the interurban system and cars of the Lewiston, Augusta and Waterville Street Railway. It also has some excellent photographs and a very complete description of the exhibit of the J. G. Brill Company at the Atlantic City convention of the American Street and Interurban Railway Association. This exhibit comprised a number of sample cars on a track alongside the pier in addition to a large amount of space inside given up to an exhibit of trucks and smaller details. The magazine also contains a number of interesting short articles, principally in connection with the "Pay-as-you-enter" cars. Some passenger and baggage cars that have been built for steam railways in the Argentine Republic are also illustrated and described.

COLLAR OILING BEARING.—The Hill Clutch Company, Cleveland, O., is issuing a small supplementary catalog which is a reprint of a portion of its catalog F, and describes collar oiling bearings in various mountings. This type of bearing is so constructed that the oil is stored in a large reservoir at the bottom of the bearing and by the means of the revolving of a split collar clamped to the shaft is continuously lifted to twin reservoirs in the upper half of the bearing, from which it is distributed to the bearing surface by gravity. The bottom reservoirs are arranged for the separation of any dirt or grit and the bearing is so constructed that the oil will not creep along the shaft and it will operate for months without refilling. These bearings are shown in practically every type of mounting, the sizes and prices of each being given in the catalog.

SCHERZER ROLLING LIFT BRIDGES.—Rolling lift or bascule bridges have such evident and numerous advantages that they are being installed in large numbers in the more thickly settled centers of population. Those of the Scherzer type form a large proportion of the best installations and this catalog, which is really an excellently written and printed, cloth bound book, illustrates a large number of examples now in operation. Part of the catalog is devoted to the development of this type of bridge, from the draw bridge of ancient times through various types of trunnion and bascule bridges. A very interesting suggestion concerning an elaborate improvement of the Chicago harbor is also discussed. A partial list of bridges now in operation or under construction, in various parts of the world, forms an interesting part of the catalog. The address of this company is Monadnock Building, Chicago.

ELECTRICAL APPARATUS.—Among the bulletins recently issued by the General Electric Co., are No. 4621, which illustrates and describes luminous arc lamps for multiple circuits. This lamp is intended primarily for use in foundries, machine shops, freight houses, etc. No. 4618 describes the new form of polyphase generator designed especially for use in small power plants and isolated lighting plants. Other bulletins are No. 4622 on polyphase maximum watt demand indicators; No. 4616 on high voltage type H transformers, and No. 4619 on steady vs. unsteady voltage.

FOUNTAIN PENS.—One of the most artistic catalogs which we have ever had the pleasure of examining is that issued by L. E. Waterman Co., 173 Broadway, New York. This is a cloth bound book of 83 pages, printed on heavy glazed paper in two colors and having emblematical illuminated drawings as chapter headings. The book opens with a chapter headed "A Dream and Its Realization," in which an account is given of Mr. Waterman's invention of the first successful fountain pen in 1883, and the wonderful development in this industry and company since that time. Following are descriptions of the method of manufacture and the operation of the Waterman pen. Excellent illustrations are given of the great variety of styles and numerous sizes in each style of pen manufactured by this company. Many of these are most elaborately mounted with gold and silver filagree work, which is very beautifully portrayed in the illustrations by means of the color work. Pens for special uses and a self-filling type of pen form the subject of another section. Pens with various emblematic mountings are illustrated, as are also various appliances for use with fountain pens, such as safety pockets, cleaners, fillers, etc.

NOTES.

GRAND TRUNK RAILWAY TO ORDER LOCOMOTIVES.—The New York *Herald* reports that the Grand Trunk Railway is in the market for 100 locomotives, which order will be placed about January 1st.

WOOD'S IMPROVED BOILERS FOR THE NEW YORK CENTRAL.—William H. Wood, Media, Pa., has recently delivered two boilers incorporating his corrugated Fire Box and flexible tube plates to the New York Central Railroad for application to consolidation locomotives. This type of boiler was illustrated and described on page 190 of the May, 1908, issue of this journal.

AMERICAN LOCOMOTIVE COMPANY.—Robert J. Gross, vice-president in charge of the domestic and foreign sales of the American Locomotive Company, has resigned to devote his entire time to other interests. James McNaughton, manager of the Schenectady Works, has been elected vice-president to succeed Mr. Gross, and W. L. Reid, superintendent of the Schenectady Works, has been appointed manager of that plant to succeed Mr. McNaughton.

LOCOMOTIVES ORDERED.—Among the recent orders of locomotives are included twenty-five 10-wheel type and fifteen 6-wheel switchers for the Chicago & Northwestern Railway and twenty-five Prairie type and thirteen 10-wheel type for the Chicago, Milwaukee & St. Paul Railway to be built by the American Locomotive Company. The latter road has also ordered twelve Atlantic type Vauclain compounds from the Baldwin Locomotive Works.

THE PARKESBURG IRON COMPANY, makers of charcoal iron, skelp, and boiler tubes, Parkesburg, Pa., have opened an office on the twenty-sixth floor of the Singer Building, New York City. Mr. J. A. Kinkead, until recently Engineer of Tests for the American Locomotive Company, has been placed in charge as Manager of Sales. Mr. Kinkead is an Associate Member of the American Society of Mechanical Engineers, Member of American Society of Testing Materials, and was for nine years chief inspector of the Chicago & Northwestern Railroad.

WARD EQUIPMENT COMPANY.—At a meeting of the stockholders of the Ward Equipment Company, held at 141 Broadway, New York, on October 12, John E. Ward was elected president; Alfred W. Kiddle, vice-president, and T. V. Bates, secretary and treasurer. A. E. Robbins was appointed eastern representative and Henry G. Horn western representative. On account of the rapidly growing business in the car heating and ventilating departments of this company, the president was authorized to either purchase or erect a suitable building in New York where the offices and warerooms of the company could be located.

CASH PRIZES FOR THESES ON AN ELECTRIC CAR DESIGN.—The J. G. Brill Company, Philadelphia, offers three cash prizes, aggregating $500, for the three best theses on the design and construction of an electric railway car for city service, open to the senior students of the technical schools of the U. S. The subject may be considered from any standpoint the student may elect and will be judged on its technical merit and on the manner in which the subject is presented. Other information concerning the contest may be obtained by addressing the Technical Department of the J. G. Brill Company, Philadelphia, Pa.

ORGANIZATION.

Motive Power Department.

LAKE SHORE & MICHIGAN SOUTHERN RAILWAY.

FOREWORD.

Being a description of what is believed to be the finest railroad motive power or mechanical department organization on this continent, not only as concerns the form of organization but what is far more important, the spirit of co-operation and enthusiasm, in working for the best interests of the road as a whole, which permeates it. It is difficult to convey by words the full force, or even a correct impression, of this spirit, which is so necessary to bring about the best results in any cause and which is so evidently the secret of the successful organization. Even those who are responsible for the development of this improved organization find it difficult to define in the abstract the fundamental principles which made it a success.

Unfortunately the subject is one which does not admit of using the art of the photographer to tempt the eye and arrest the attention of the reader, thus encouraging him to study into its details. We believe, however, that it is the most important article which has ever appeared in this journal, and we urge our readers to give it careful consideration, no matter what department or class of work they are engaged in, for the general principles underlying it are applicable to any organization. No more important problem is before the railroads to-day—not only in the mechanical, but all departments—than that of efficient organization.

In connection with the study of this subject some important features were noticed, which, while they are not strictly matters of organization, are an outcome of it and were closely allied to its development. We have included a description of a few of these features, such, for instance, as the engine-house work reports and the effect of these and the efforts of the mechanical engineering department in reducing the number of engine failures. To assist in the study of the organization charts a map of the system has been included.

WHAT IS A GOOD ORGANIZATION?

The effectiveness of an organization must be judged by its ability to increase the efficiency of the department, or concern, as a whole. This result can only be obtained by improving the efficiency of each individual in the organization, from its head to the least important employe. This requires ample supervision working along definite lines and based on certain important fundamental principles.

It is possible for a strong and gifted leader, by pure force of personality and with a poor organization to back him, to bring about fair results; but, let him leave it even for a short time and the efficiency immediately falls off. It is further true that in a large organization of this class he cannot bring the efficiency above a certain point because he will be swamped by details, even though he is of exceptional capacity, and cannot give sufficient thought and attention to the larger problems which must be solved to guide it properly.

One of the cardinal principles of a good organization is that every officer and foreman in it should see that he has under him a man who can successfully take his place, either temporarily or permanently. A test of a good organization is whether the efficiency is appreciably affected by the absence of any one man.

Good organization means that there is team work and co-operation between its different branches or departments, in fact that department lines are practically lost sight of, and the men press on enthusiastically, shoulder to shoulder, not for the success of any one department, but for the success of the organization as a whole.

To make an organization permanent, it is necessary to have the line and staff officers in direct accord with the policy of the head of the department. This policy and the form of organization must be so clearly understood that each line and staff officer is a capable instructor of those under him. This can only be done by earnest and enthusiastic effort on the part of all men in authority from the top to the bottom of the organization.

GENERAL PRINCIPLES UNDERLYING A GOOD ORGANIZATION.

The general principles are not by any means arranged in the order of their importance; as a matter of fact it is questionable if it would be possible to do this. Ask any of the men who have been most enthusiastic in developing the organization on the Lake Shore what they consider to be the most important principle underlying it and they will stop, and think a moment, and then relate an incident illustrating some phase of it which has specially appealed to them. The principles, which are outlined below, represent in a general way the thoughts which were brought out in this manner.

Good Leadership—Team Work—Enthusiasm.

An efficient organization demands a strong leader who can command the confidence of the men and who is able to enthuse and bring out the very best in each of them; not this only, but his subordinates must be developed to have the same influence on those reporting to them, and so on down to the men in the ranks. An officer or subordinate who is not capable of being thus developed has no business holding a responsible position in the organization. A spirit of loyalty and co-operation must be built up and permeate the entire organization. The establishment of this spirit of team work dates from a change in the motive power department organization which was made about ten years ago. Upon this as a foundation a complete reorganization of the department has taken place during the past few years. The development of this esprit de corps will result from the application of the following principles.

Synopsis.

Eligibility to Promotion.

No man is eligible to promotion unless he has a man under him who can step up and take his place and produce as good or better results.*

It should not be necessary to go outside the organization for men to fill any position, even the highest, but all appointments should be made from within it. Surely something is radically wrong when a railroad, employing thousands of men in the mechanical department, must go outside the organization for its officials. Is it because the proper material is not there, or cannot be developed, or is it because the men who are making the appointments are not keen enough to discover it, or have such a poor organization that good men cannot be developed? Such things may be excusable when conditions are so bad that it is necessary to effect a complete reorganization, but this conditon should not exist long thereafter.

It is distinctly understood by all that in order to receive a promotion each must have a man under him capable of filling his position, and must necessarily have previously called the attention of his immediate superior officer to the qualities of this man in order that he may be familiar with the development of the growing organization.

Promotion of Men from the Ranks.

The men selected to be promoted from the ranks receive the most careful consideration for they must have those qualities, which properly developed, will fit them for the highest positions in the organization. This is especially important from the fact that if such men are promoted and are not capable of being developed to a certain point, they block the way for advancement of the men under them. It is a mistake, after a man has once been promoted from the ranks, to reduce him, for he will be dissatisfied and become a menace to the organization. For this reason and in justice to the men, they should be promoted only after the most careful consideration.

Taking Officers and Foremen from the Organization.

An organization may be likened to a triangle, the rank and file composing the base, the head the apex, and the department heads and their subordinates the space between. If a number of lines be drawn from the base to the apex, they may be considered the paths along which promotions are made. In advancing upward a man may jump from one line to another, but the progress will always be upwards. If men are to be transferred to some

* This is contrary to the old idea which is indeed still held by many men in more or less important positions. We have all met men, either in the shop, on the road, or in the office, who insisted on doing certain things themselves and seemed to surround the operations with mystery, giving the impression that they were beyond the understanding or ability of the average man. How surprised we often were, when we discovered the details of the process, to find how simple it really was. The official or foreman who imagines that he can strengthen his position in the organization by doing this is making a big mistake. He can make a much better record by shifting as much detail as possible on his subordinates, thus giving him more time for the general study and direction of the work.

If a man under you is doing exceptionally good work, or has discovered a new and better method or device for doing the work, give him the proper credit and let it be known. Both he and those about him will be encouraged to do better work and the efficiency of your department will be correspondingly increased. It is the men who are big enough to encourage and develop the men under them, in this way, that are fast filling the most responsible positions on railroads and in industrial establishments. The "one man" business, or department, is becoming a thing of the past.

other organization it is better that they be taken from near the top in order to give as many men as possible an opportunity for promotion.

Permanency of a Good Organization.

A question which will undoubtedly suggest itself to the reader, is, what will happen if the head of the department is taken away. With the organization properly and well established, it would make no difference, as the officers and foremen have gradually developed and absorbed the spirit of the organization.

If a man reaches a certain position and does not line up properly his associates, who come in contact with him, will undoubtedly bring pressure to bear upon him, and if he does not "line up" he will be forced out. Suppose, for instance, that a master mechanic, newly appointed, develops traits which cause friction between himself and another master mechanic, or possibly, the shop superintendent or mechanical engineer. These three men, who are accustomed to team work, will get together and talk the matter over, after which they will possibly arrange to meet the master mechanic in question and frankly talk matters over with him. If he is the proper kind of a man for the position he will see the point and co-operate with his associates; if not, the best thing for him to do is to step out. In this way a good organization, when once well established, develops itself and any man, no matter what his position, will be automatically eliminated or wedged out if he does not conform to its principles. Thus a man who reports directly to the superintendent of motive power and is in intimate touch with him, must necessarily have the proper stuff in him and have absorbed the principles which made the work a success, and will, therefore, be especially well fitted to take his place if his superior should be called away.

Supervision.

An examination of the diagrams or charts of the organization of the different branches of the department shows that a very thorough and complete supervision has been provided for. It is difficult to realize the amount or extent of supervision until it is properly diagramed. When an organization cannot be properly diagramed, its weakness becomes apparent. The very act of making supervision charts is a liberal education.

The great difficulty is that the matter of supervision is not given sufficient attention, probably because added supervision apparently increases the expense of the department. As a matter of fact there are very few roads which could not increase their supervision quite largely, with a resulting increase in efficiency of the department as a whole.

Too often a high salaried officer is handicapped by a large amount of details which should be handled by his subordinates. A high salaried man without this assistance is often only giving his company a small proportion of the returns which he could if he had the proper assistance.

Specialization.

One of the fundamental principles of efficient organization is the specializing of work to a high degree. This is not only true of the rank and file, where the object has been to some extent accomplished by the adoption of piece work, but also throughout the service and especially in connection with the general staff where each man is an expert in his particular line.

Relation of Officers to Subordinates.

Criticism of subordinates is constructive, not destructive. Petty fault-finding is eliminated and the superior officer in a firm, patient, diplomatic way encourages and develops the subordinate by showing him how to remedy and overcome his weak points. The development of many good men is often stunted because of a spirit of fault finding on the part of their superiors.

It is difficult for even a good man to retain his self-respect and the enthusiasm which he should for his work, when in receipt of such letters as are sent out daily on many roads.*

The subordinate knows that it is his duty and privilege to speak frankly to his superior. The officers invite frank criticism from the men under them, realizing that in many instances they are closer to the actual work and often better able to judge from the particular standpoint than they are.

Young Men and Responsibility.

Young men are developed and promoted to positions of responsibility. The reasons for this may be briefly stated by quoting from an editorial in our January issue:

"One of the common faults in those who have the management of large forces is that of not thoroughly understanding the elementary fact that if we desire to keep our positions as foremen and executives, it is necessary to keep our forces young. To make this clear it may be truly said that if we keep our forces young it does not matter how old we may be ourselves, we will be practically sure of retaining our positions.

"It should be distinctly understood that men are capable of accepting positions of responsibility when they are very young. As an illustration we might say that when a man is twenty-one he should be advanced to a position of responsibility where it is necessary for him to handle a number of men. The common fault lies in the fact that we usually consider those under us young if they are slightly younger than ourselves."

---

* A man who has come up from the ranks—a big broad fellow, physically and mentally—and now holding a position near the "top of the heap," when in a confidential mood told of the following experience. He had been promoted to the position of master mechanic and was stationed on one of the worst divisions of a northwestern road. Storms and blizzards had blocked the road but by almost superhuman efforts, and at the risk of life and limb, the power had been maintained and the blockade broken, largely because of his efforts. He was congratulated by his superiors and naturally felt more or less pride in the achievement, especially since, although a new man, he had demonstrated his fitness for the position.

The superintendent of motive power was very friendly and apparently took a great interest in him, but, as the master mechanic expressed it, he would receive the "nastiest" kind of letters from headquarters criticizing or calling attention to comparatively unimportant details. He finally became discouraged and made up his mind that if he was to keep his self-respect it would be necessary for him to resign at once. He took the matter up with the superintendent of motive power and was told to go back to work, that his services were entirely satisfactory and that he should not take things quite so seriously, *as it was the business of the superintendent of motive power to find fault and criticize those under him.* A good many people seem to be afflicted with the same idea, at least to some extent, but it should have no place in a good organization.

Check of Individual Efficiency.

An important feature of the organization is the system of checking the efficiency of the men. The individual efficiency of a large percentage of the mechanics in the shops has been improved by the introduction of piece work, the results of increased efficiency being largely proportional to the study, care and common sense given to installing it properly.* At the present time practically all of the car department repairs and a large percentage of the locomotive shop repairs on the Lake Shore are done on a piece work basis.

The New York Central lines apprenticeship system** is a decided success and is gradually developing a superior class of mechanics for the perpetuation of the organization.

The individual efficiency records which will eventually cover all the men within the organization of the motive power department, have already made a material improvement in the personnel of the organization.

Records and Statistics.

It is important that accurate records and statistics be kept so that comparisons may be made from month to month and that the costs may be analyzed. In doing this, care should be taken not to pile up a lot of useless or unreliable records. This is too often the case. It is also important that these statistics be arranged so that they may be studied by the officers at the expense of a minimum amount of energy. Graphical records may often be used to advantage.

While system is a vital point in a good organization it should be remembered that common sense must govern in all cases and that too much system is often far worse than not enough.

* A valuable article entitled "Piece Work," with particular reference to the car department, although the general principles apply equally well to the locomotive department, contributed by LeGrand Parish, appeared in the September, 1904, issue of this journal.

** A complete description of the New York Central Lines apprenticeship system appeared in this journal during 1907 and may be found in the June, July, September, October and November issues of that year. An abstract of the proceedings of the second annual conference of the apprentice instructors will be found in the October, 1908, issue. The vital principles of a successful apprentice system, as outlined by the apprenticeship committee of the Master Mechanics' Association, and which have recently been adopted by letter ballot as the recommended practice of that association, will be found on page 276 of the July, '08, issue.

GENERAL ORGANIZATION.

A study of the chart showing the general organization of the motive power department brings out several interesting features. For instance, the mechanical engineer is an executive officer, being next in command to the assistant superintendent motive power. When given this importance in the organization the machinery at his disposal can be keyed up to such a pitch that it really becomes the keynote of the mechanical department, and so it should be. Unfortunately this holds true on very few roads and, as a matter of fact, it cannot be true where the mechanical engineer's department is from three months to three years behind the rest of the department, showing that its work consists largely of recording what has already been accomplished. When it is given sufficient backing to lead the other departments, then it assumes its real importance and takes its proper place in the organization.

It will be seen that the general form of organization is quite similar to that of an army, and consists of a line organization made up of the superintendent motive power, assistant superintendent motive power, mechanical engineer, master mechanics, master car builders and superintendents of shops, and so on down to the men in the ranks. There is also a general staff consisting of the chemist and engineer of tests, a supervisor of materials, supervisor of boilers, supervisor of locomotive machinery, supervisor of air brakes, supervisor of safety appliances, supervisor of steam heat and lubrication, supervisor of electrical construction, supervisor of valve motion and general shop inspector.

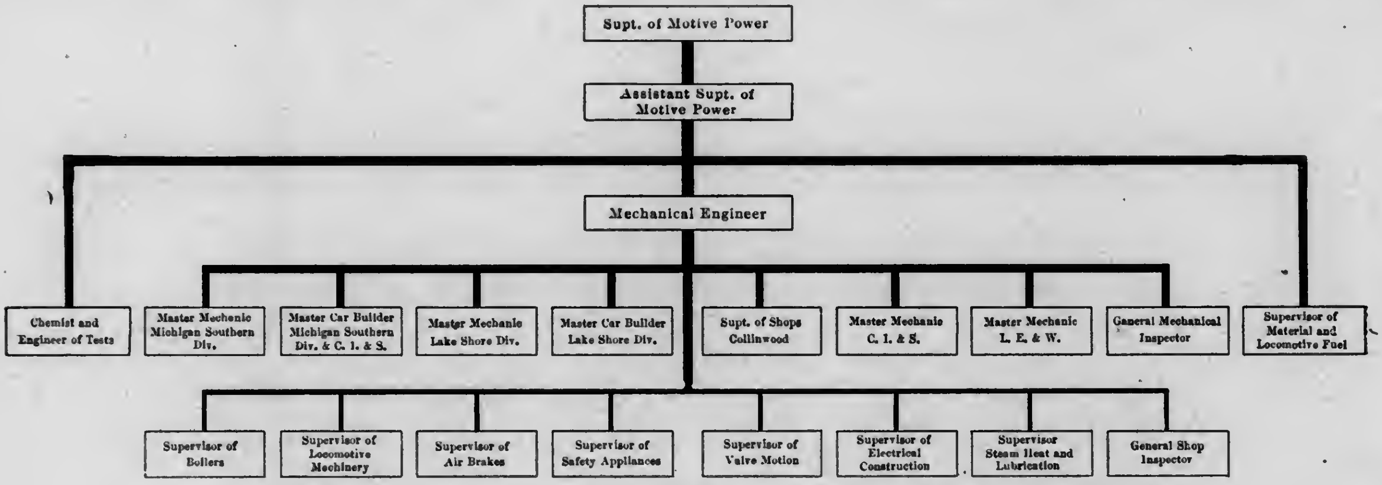


CHART SHOWING THE GENERAL ORGANIZATION OF THE MOTIVE POWER DEPARTMENT.

The supervisor of materials examines and checks all requisitions and keeps in touch on the road as regards all material, including fuel.

The chemist and engineer of tests reports direct to the assistant superintendent motive power, and has direct supervision over all physical and chemical tests in all departments.

The advantages of this form of organization were briefly considered in an editorial in the October issue. The men on the general staff are carefully selected and are specially fitted to take charge of the work to which they are assigned. They give their entire time to studying and improving the conditions of their special work and co-operate closely with the line officers in seeing that such instructions as have been issued are carried out, and that the efficiency is raised to the highest possible point. The general staff meets with the superintendent motive power every two weeks. In the absence of the superintendent motive power the meeting is in charge of the assistant superintendent motive power, and in his absence is conducted by the mechanical engineer.

The first action considered at these meetings is always one concerning the saving of either labor or material. This is a standing subject which is very freely discussed. In addition to this each member of the staff is assigned subjects pertaining to his particular line. These subjects are usually developed from sug-

gestions made at staff meetings and are open to discussion by all members of the staff. The educational value of this system will be readily understood. These meetings have been held for the past two years with excellent results. Before this form of organization was developed it was not possible to get the same efficiency because efforts of the staff members were individual rather than concerted. Soon after these meetings were started it developed that their duties were no longer those of inspectors but of supervisors and their titles were changed accordingly.

The first meetings of the general staff under the new order of things were rather dull, until after careful coaching they came to understand that they were expected to suggest and furnish the information on which the superintendent motive power was to base his instructions; and still more, that it was necessary for them to practically formulate the working instructions for the class of service over which they had jurisdiction.

The efficiency of these men and, as a result, the efficiency of the organization, has been considerably improved by having it clearly understood that they are in no sense detectives, but that their duty is to cordially co-operate with the line officials in bringing up the efficiency and standardization of the work in their branch of the service. When the staff officers see anything which needs attention it is taken up with the local official. If the matter is peculiar to that one locality, the local officer promptly takes the necessary action. If, however, it is general, it is taken up at the general staff meeting.

Because the staff officers are specialists it must not be considered that the staff meetings are at all one-sided and dull. Most subjects which are considered in some way touch upon the interests of several members of the staff, and as all of these officers are men of more or less general experience and are constantly going over the road, they are, of course, familiar with the conditions affecting almost any branch of the service. They do not hesitate to call attention, in a good-natured way, to things which they have seen can be improved and are under the immediate charge of other members of the staff. The discussions are very frank and to the point, but underlying them all is a strong feeling of co-operation.

The staff has a secretary who keeps the minutes of the meetings and to whom they report their location each day; in this way it is possible to reach them quickly at any time. While these reports indicate the special work upon which they are engaged at the time, it must not be assumed that they are hampered by instructions, for inasmuch as they are held responsible for the improvement of their branch of the work, they are necessarily free-lances and many valuable improvements have been made at their suggestion.

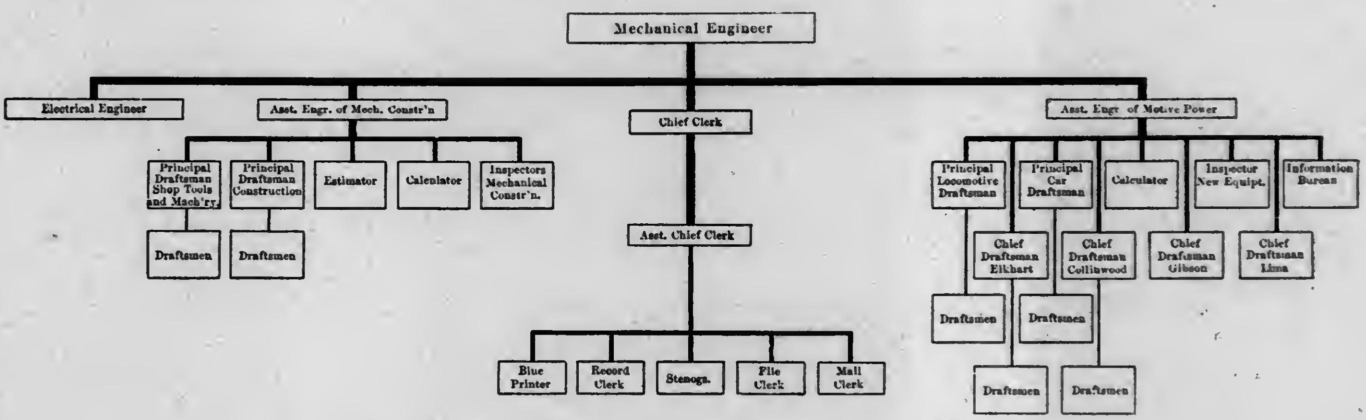
The line officers meet with the superintendent of motive power once a month for general discussion of matters pertaining to the department. The line officers also hold meetings with their subordinates at regular intervals on matters pertaining to their respective divisions, and so on down the line. In connection with the meetings of the line officers different topics which are under investigation are frequently referred to committees for special study.

The difference between the organization on the Lake Shore and the United States army organization is that promotions are not entirely by seniority, although in the past few years the army has changed considerably in this respect. As a matter of fact, a man who is incapable of being promoted is eliminated as quickly as possible from the organization. Quite often several officers are in line for promotion to a position which is open; generally speaking it is given to the man who possesses the greatest merit.

ORGANIZATION OF THE MECHANICAL ENGINEERING DEPARTMENT.

The mechanical engineer's department is considered at this point, because it is one of the most important branches of the motive power department, since it should anticipate the wants of the other branches and keep in advance of them. The fact that the mechanical engineer is an executive officer, as shown in the preceding section of this article, has done much to bring up the efficiency of the department as a whole.

Under the former system the chief draftsman, reporting direct to the mechanical engineer, had in charge the design of all rolling stock and was in charge of the clerical force and looked after the routine correspondence of the department; the draftsman in charge of shop tools, machinery and construction, was supposed to report to him. Under these conditions he was swamped with so much detail and routine work that he had very little time to give to the broader work of directing the maintenance design of equipment.



ORGANIZATION OF THE MECHANICAL ENGINEERING DEPARTMENT.

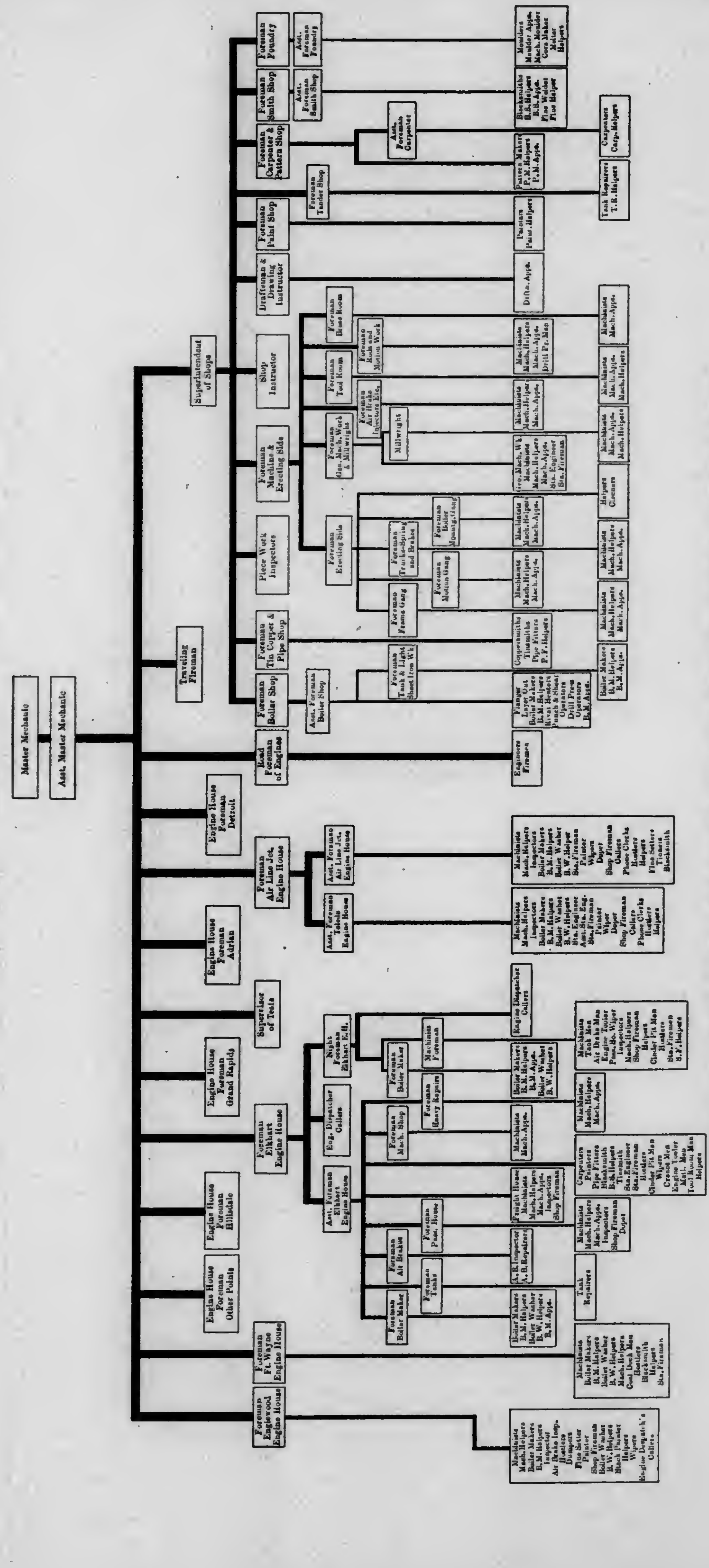
Under the present arrangement the mechanical engineer has three men reporting direct to him, each one of whom is responsible for a certain line of work, as indicated by their titles, although necessarily their interests often dovetail so that they must co-operate closely with one another.

The assistant engineer of motive power is in charge of matters relating to the maintenance design of locomotives and cars.

The assistant engineer of mechanical construction is in charge of matters relating to shop and enginehouse equipment, shop tools and machinery.

The electrical engineer is a new member of the organization and has in charge all matters relating to the engineering of electric power and lighting. It has been said in a previous section of this article that all promotions should be made from within the organization. To show the extent to which this has been followed in the past few years it might be of interest to know that this is the only important official who has been taken from the outside, and this was only done because there had been no opportunity to train such a man within the organization.

The mechanical engineer's department was handicapped by being too far away from the "firing line" or actual "seat of war." Its headquarters on most railroads are so far removed that it has no way of keeping closely in touch with the principal shops, except through correspondence. Not having responsible repre-



ORGANIZATION OF THE MASTER MECHANICS' OR LOCOMOTIVE OPERATING DEPARTMENT—WESTERN DIVISION.

sentatives at these points, the importance of a great many matters is not fully realized and action which should be taken immediately is either entirely overlooked or does not receive final attention until long after it first comes up.

For this reason a first-class man on the mechanical engineer's staff has been placed at each of the principal shops, having the title of chief draftsman. Practically all of these shops are so located that the chief draftsman can keep in close touch with the master mechanic, master car builder and shop superintendent. These men, as soon as any difficulty arises, or whenever they have any suggestions to make looking toward improvements, call the chief draftsman in and lay the matter before him. He looks into it carefully, submitting the recommendations, with drawings, to the mechanical engineer. The chief draftsman, in preparing these recommendations, consults with the several foremen who will have to make, finish and apply the device, and in this way it is considered from the erecting and manufacturing standpoint, as well as from that of theoretical design, with consequent better results than when the work is handled entirely in the main drawing room.

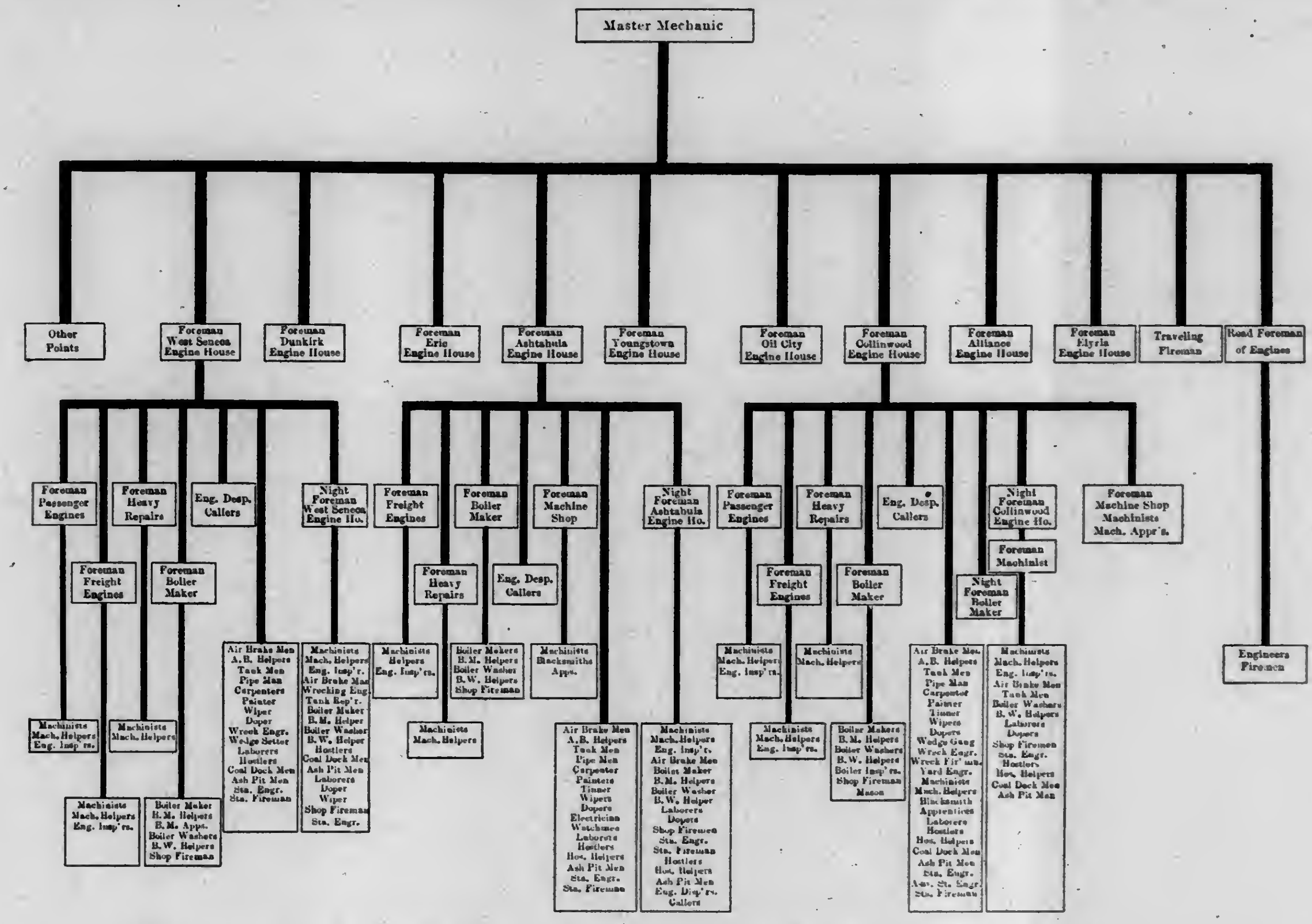
An indication of the effectiveness of these men is shown by the fact that when they were first appointed it was felt that the crowded condition of the main drawing room would be relieved, but the amount of work they dug up and got under way proved quite the reverse. The chief draftsmen give special attention to the study of broken and badly worn parts. Formerly broken parts were usually only called to the attention of the mechanical engineer when they were responsible for engine failures.

Another good result is that due to the close co-operation of the chief draftsman with the local officers there is a much better understanding of the standards and drawings.

In order to keep the chief draftsmen at the shops in close touch with headquarters, they meet for conference with the assistant engineer of motive power, to whom they report, every two weeks.

In the main drawing room the principal locomotive draftsmen and principal car draftsmen each have several detail draftsmen and tracers reporting to them. The work is liable to more or less fluctuation and workmen are transferred from one class of work to the other as necessity requires.

In addition to the draftsmen, a calculator is employed, whose work consists of calculating stresses in materials, or other calculations, most of which are seldom worked out by the average draftsman; in consequence much time is saved. The regular draftsmen work only the simpler problems, the more difficult ones being referred to the cal-



ORGANIZATION OF THE MASTER MECHANICS' OR LOCOMOTIVE OPERATING DEPARTMENT—EASTERN DIVISION.

culator. The calculator also receives all data as to broken or worn parts of locomotives and cars, analyzing the breakages and recommending improvements in design, where found advisable.

The information bureau is another important feature of this office. The drawing room is constantly in receipt of inquiries from the superintendent motive power's office, other departments, and from outside sources. Ordinarily this would take a large amount of time of men who have other important work to look after, and for this reason one man has been detailed to look up and obtain all information which is necessary to promptly and properly answer the inquiries.

The cost of all work done in the drawing office is accurately distributed; each job is given a number and each draftsman turns in a work slip every night showing the time he put in on each job during the day. A record is kept from which can be shown the actual cost of every job which is done. A time limit is set on each job and it is followed up to see that it is completed promptly on the scheduled time.

ORGANIZATION OF THE MASTER MECHANICS' OR LOCOMOTIVE OPERATING DEPARTMENT.

There are two master mechanics on the Lake Shore, one having charge of the territory east of Toledo, and the other having charge of Toledo and territory west. The general principles governing the form of organization are the same for each. The conditions are so different that, as may be seen, the charts differ more or less in detail. The master mechanic of the Eastern division has three large and important enginehouses under his jurisdiction, Buffalo (West Seneca), Ashtabula and Collinwood. A considerable amount of heavy running repairs are handled at Ashtabula and Collinwood, necessitating a machine shop in connection with each of these enginehouses.

On the Western division the master mechanic, in addition to the road work, has charge of the shops at Elkhart. The extensive district covered by this division makes it necessary for him to have an assistant. The general foreman at Air Line Junction is in charge of the enginehouses at Air Line Junction, Toledo, and several less important points. The general foreman at Elkhart has supervision over the enginehouse at Elkhart, and several less important points. The superintendent of shops is in direct charge of the Elkhart locomotive shops, the arrangement of the organization being clearly shown on the diagram.

Individual Efficiency Records.

The master mechanic has in his desk what is known as an efficiency card for every fireman and enginehouse employee. Eventually, he will have a card for every man under his charge. One of the fundamental principles of good organization is that the efficiency of each man be increased to the maximum. The efficiency of such men as work under piece work is automatically increased, but necessarily a large proportion of the men do not come under this head, so that a gauge must be placed on them, making it possible to determine their general efficiency and characteristics. By thus locating the poor and weak men they can be encouraged to improve, and if they do not show the necessary improvement, they may be dropped from the service.

It is to be feared that the foremen in many cases do not take a sufficient interest in studying the personalities of the men under them, or they may be burdened with routine work and do not find much opportunity for doing this. The efficiency card system not only makes it necessary for them to do this, but makes readily available a record of each man in the organization. The efficiency cards also enable the foremen to properly select men for promotion, as they must be observant and study the men under them closely, in order to properly fill out the cards.

A set of these cards is made out at intervals of about six

months. The road foreman of engines is furnished just enough cards so that there will be one for each man under him. He keeps no copy of his records and in this way, each time he makes out a new card it will be unprejudiced by any former report. That these efficiency cards are having a good effect is evidenced by the fact that it is not uncommon to have firemen inquire about them, showing that they realize the importance of their existence. They fully understand that the road foremen consult the enginehouse foremen and enginemen as to their performance and habits. This makes them much more eager to please and results in better service to the company. It also improves the standing of the road foremen of engines among the men and in the organization.

That the road foremen are studying the men closely is indicated by the fact that of thirty firemen who failed to pass the first and second year progressive examinations for different causes and were dropped from the service, the efficiency cards of all but two showed poor. The good effects of these efficiency cards will be more apparent when additional sets come in. The new efficiency cards are compared with the last set marked up and checked with all former cards by the master mechanic, and those men who have had a poor record and do not show improvement are called in and shown the cards; their weak points are indicated and they are encouraged to improve. The fireman cannot escape the fact that his record will go before the master mechanic as, under this system, the attention of the master mechanic is directed to the service of each individual.

An examination of these cards also brings out the fact that the personality of the road foremen of engines is reflected in them; that is, a road foreman of engines whose ideals may not be of the very highest will mark a fireman higher on certain things than would another with higher ideals. Of course, it is advisable to eliminate the matter of personality, and in so doing, it is necessary to educate the road foremen along certan lines, this being done by stated meetings between the master mechanic and the road foremen, and by quiet talks which the master mechanic has with them as occasion arises.

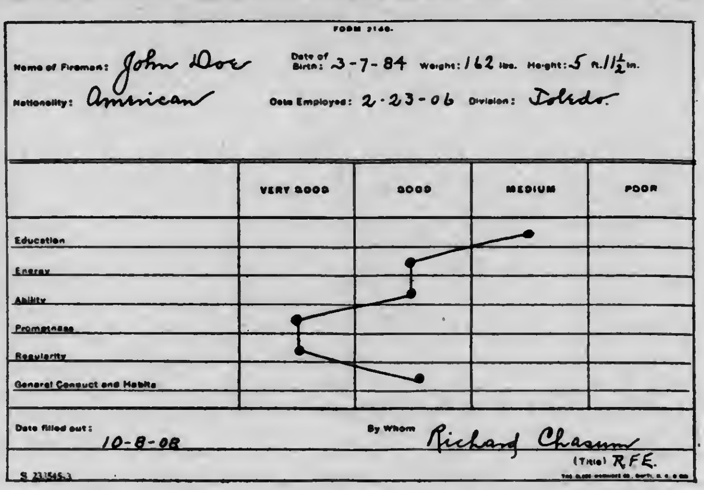
An interesting fact developed in connection with the selection of what is known as student instructors of firemen. These are capable first-class firemen who are selected to instruct the student, or new fireman. The student firemen are assigned to accompany the instructors on their runs in the performance of their regular duties. The road foremen of engines were asked to carefully select a certain number of these men. Their names were sent to the master mechanic who confirmed the appointments. He found, on examining the efficiency cards of these men, that in every case they had splendid cards.

The master mechanic received the following letter from the superintendent of motive power while the writer was talking to him about the efficiency cards:

"Referring to your letter of the 2nd inst., relative to the dismissal of Mr. Blank. Will you kindly send me the latest efficiency card filled out for this man?"

Reference to the card showed that the man in question did not have a favorable card, as it was marked "Medium" on all points.

Two typical reports for firemen are reproduced for illustration: one showing a good card and the other a questionable one. If the man giving poor service has the right sort of stuff in him and the next report does not show an improvement, it should be possible to develop him along the proper lines by calling him in, showing him his card and pointing out the weak points.



FORM 2140.

Name of Fireman: John Doe Date of Birth: 3-7-84 Weight: 162 lbs. Height: 5 ft. 11½ in.

Nationality: American Date Employed: 2-23-06 Division: Toledo.

	VERY GOOD	GOOD	MEDIUM	POOR
Education				
Energy				
Ability				
Promptness				
Regularity				
General Conduct and Habits				

Date filled out: 10-8-08 By Whom Richard Chasum (Title) R.F.E.

S 231545-3

INDIVIDUAL EFFICIENCY CARD FOR FIREMEN—A GOOD MAN.

Power Meetings.

Every three months a power meeting is held in the office of the master mechanic, at which the road foremen of engines, enginehouse foremen, shop superintendent and his assistant, and general foreman are present. The master mechanic has a card index before him showing the condition of each locomotive boiler when last reported (sample cards are shown in the accompanying illustrations). As the engine number is called out, the road foreman of engines under whose jurisdiction it comes, reports on the condition of machinery. If the conditions are such that it will be necessary to make repairs during the next three months, the class of repairs and the month during which the engine will be shopped are decided upon.

A typical report of the result of a power meeting follows:

Engines that will need repairs during the month of—

Collinwood Locomotive Shop.

4594	E. H.—½ F.	4842	2 F.
4651	E. H. F.	4843	E. H. F.
4682	4 sheets.	5804	E. H. F.
4684	E. H. F.	5807	E. H. F.
4688	E. H. F. tires.	5818	E. H. F.
4720	2 F.	5822	E. H. F.
4728	E. H. F.	5841	E. H. F.
4729	E. H. F.	5843	I. F.
4733	E. H. F. tires	5871	2 F.
4800	2 F.	5875	2 F.
4801	2 F.	5940	1 F.
4805	E. H. F.	5973	1 F.
4813	E. H. F.	5975	1 F.
4815	2 F.	5993	2 F.
4816	2 F.	5996	2 F.
4820	2 F.	5842	1 F. 4 sheets.
4726	E. H. F. May want new F. sheet.		

Ashtabula.

4302	2 F. cut out.	4302	E. H.
4469	E. H. Tires.	4416	E. H. Tires.
4424	E. H. Tires.	4434	E. H. Tires.
5149	E. H. Tires.	4329	E. H. Tires.
5304	E. H. Dr. Boxes.		

Collinwood.

4309	E. H. Tires.	5134	E. H. ½ flues.
4429	E. H. Tires.	5119	E. H. Tires.
4538	E. H. Tires.	4310	E. H. Tires.

West Seneca.

4464	E. H. Tires.	4512	E. H. Tires.
4472	E. H. Tires.	4513	E. H. Tires.
4495	E. H. Tires.	4517	E. H. Tires.
4505	E. H. Tires.		

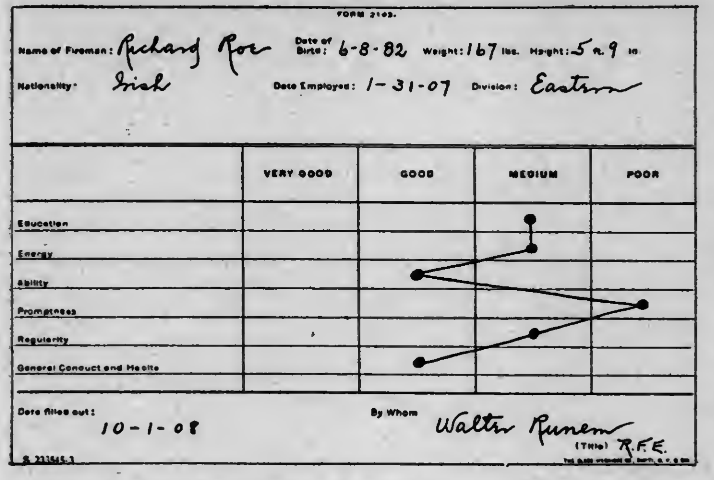
Classification of Locomotive Repairs.

Class 1—General repairs to machinery.
Class 2—Light repairs to machinery.
Class E. H.—Enginehouse repairs.
Class A—Accident repairs.
Class W.—Wreck repairs.
Letter "F" is suffixed to any of the above classes to indicate flues renewed.

It will be noted that the first part of the report shows the engines which will be taken to the shop, while the latter part shows those which are assigned to the different enginehouses for repairs.

Every week the master mechanic, shop superintendent and assistant shop superintendent, and such of the road foremen of engines as may be in the vicinity, hold a meeting and talk over the condition of engines which are to be shopped the following week. Having before them the power report they are enabled to select such engines as will keep the work well balanced.

When an engine requiring E. H. repairs is sent to the shop the



INDIVIDUAL EFFICIENCY CARD FOR FIREMEN—A QUESTIONABLE MAN.

master mechanic furnishes a work report; other work which the shop finds necessary, or thinks advisable, is referred to the master mechanic.

Enginehouse Work Reports.

An important improvement in the enginehouse organization has been effected by developing a system to properly take care of the reporting and checking of all work reported on locomotives. This includes a suitable file case for filing all finished and unfinished work cards, separately for each locomotive, so that, if desired, the name of the workman who made the repairs can easily and quickly be found. Thus if an engine failure takes place, due to improper repairs, or neglect at an enginehouse, the responsibility is easily located. In such cases, the enginehouse foreman is required to report the name of the man to the master mechanic and to make an exact note of what discipline, if any, was administered.

It is believed that this improved method of handling the enginehouse work reports is very largely responsible for the marked reduction in engine failures during the present year, as is shown on the accompanying diagram (page 462).

The actual figures showing the number of miles per engine failure in both freight and passenger service, the total number of miles made in each class of service, the number of failures and percentage of increase or decrease during each of the past four months, as compared with the record of the same four months for last year, are shown in the accompanying table.

An engine failure on the Lake Shore is defined as a delay to a train, due to any mechanical inefficiency, of three minutes in passenger and ten minutes in freight service. An engine failure is charged, although all of the lost time may be made up between terminals.

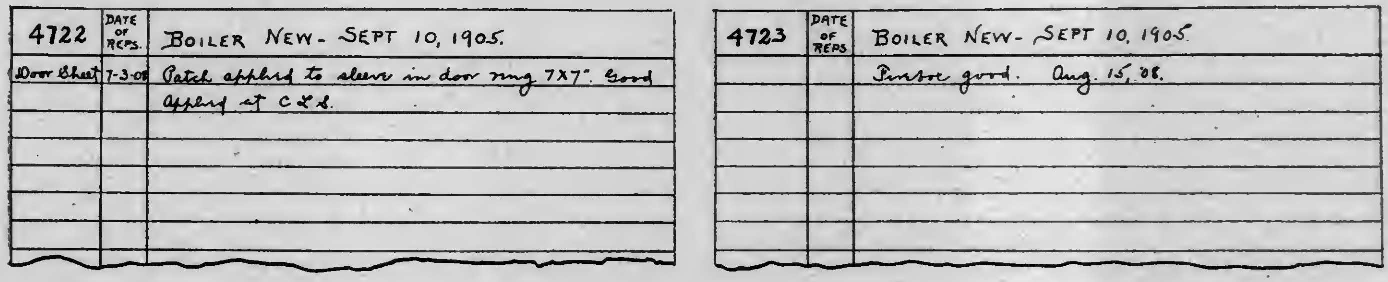
When an engineer comes in off his run he verbally reports the work which is necessary on the engine to a clerk at the work report office. The clerk writes the report in a work report book and the engineer reads it, and if correct, signs it. In this way the reports are always kept clean and legible. The clerk makes out the work slips from the report book on a form about 3 x 5 in., similar to the one shown in the illustration; a separate slip is made out for each job. When the work cards have been made out, the clerk marks the work report in the book O. K., with the figure 1 or 2 underneath, showing that the items have been copied on work slips; 1 indicates that the cards have been made out by the day clerk and 2 by the night clerk.

The cards are placed on the engine foreman's desk along with all incomplete work reports (work reported but not done when engine was last in the house) for that particular engine; these latter cards are taken from the incomplete pigeon-hole, of the engine in question, in the file case.*

The passenger work cards are turned over to the passenger engine foreman and the freight and switch engine work cards are given to the freight engine foreman. These in turn distribute them to the various gang foremen or workmen, as the case may

* These file cases consist of pigeon holes 3¼ in. wide and 3 in. high, one for each engine, sub-divided by tin slides so that the upper section, ¾ in. high, may be used for incomplete work cards, while the lower part, 2¼ in. high, is used for finished work reports.

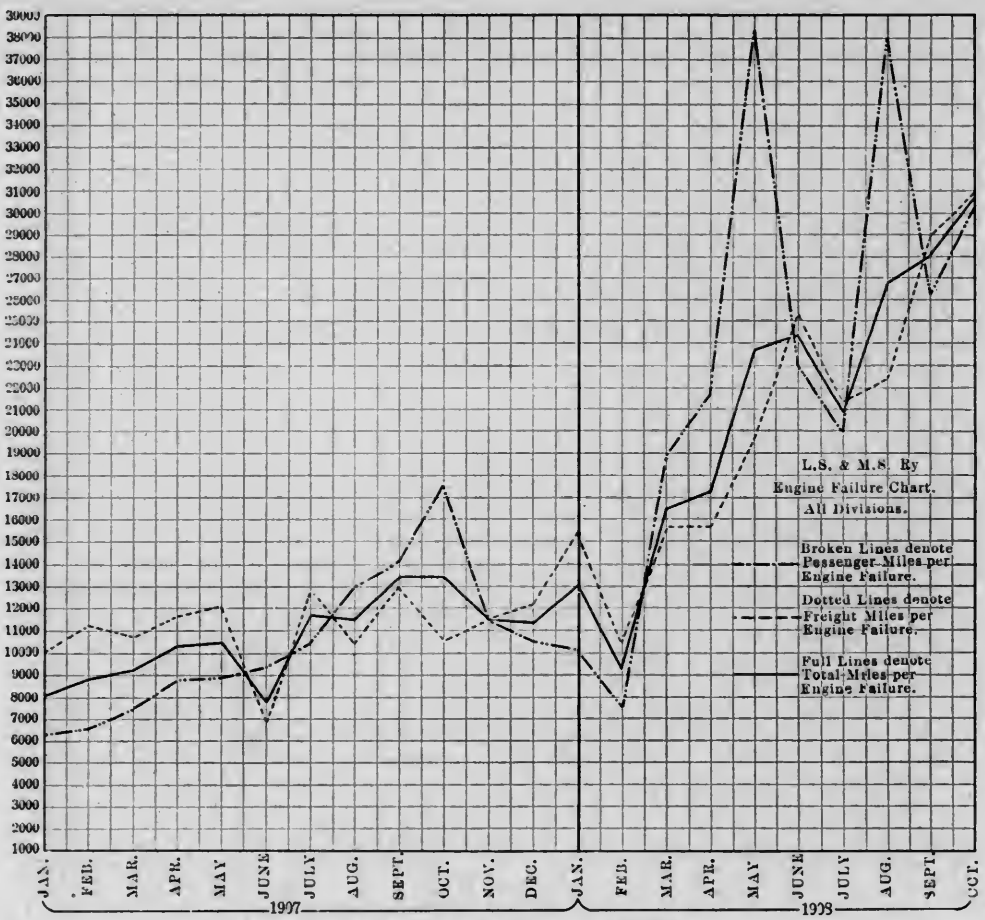
These files are in the office of the clerk, in which no one is allowed to enter but the clerk and the engine-house foreman. The engineers' reports are dictated through a window. The hostler reports the engine numbers as soon as the engines are placed in the house or on storage track, so that the clerk can immediately place the incomplete work reports, if there are any, on the foreman's table.



TYPICAL INDEX CARDS SHOWING THE CONDITION OF BOILERS. ENGINE NUMBER IN THE UPPER LEFT-HAND CORNER. CARDS ARE 4 x 6" IN SIZE.

			July.	August.	Sept.	Oct.
Miles run per Engine Failure	Passenger	08	19,948	37,939	26,191	30,153
	"	07	11,468	13,697	15,549	22,331
	Freight	08	21,308	22,525	29,048	30,896
	"	07	27,722	18,290	23,220	19,835
Number of Miles Run	Passenger	08	738,089	758,777	707,144	723,663
	"	07	756,877	794,418	761,923	781,569
	Freight	08	1,214,572	1,351,496	1,336,209	1,452,107
	"	07	1,580,138	1,591,232	1,578,980	1,765,327
Number of Engine Failures	Passenger	08	37	20	27	21
	"	07	66	53	49	35
	Freight	08	57	60	46	47
	"	07	69	87	68	89
Per Cent. Inc. or Dec. Miles Run per Engine Failure	Passenger	08	74	177	68	35
	Freight	08	23 Dec.	23	25	56

RECORD OF ENGINE FAILURES FOR JULY, AUGUST, SEPTEMBER AND OCTOBER, COMPARED FOR 1907 AND 1908.



ENGINE FAILURE CHART—ALL DIVISIONS.

be, and when the work is completed, or at the close of the work period, receive them back. The engine foremen distribute and receive the cards so that they may have an exact knowledge of all of the work reported and in order that they may promptly report the engines for service when the work is completed.

If any of the inspectors or foremen discover unreported work, a report is made out and handed to the clerk, who copies it in the work report book, and the card is handled the same as engineers' cards.

As soon as the work has been completed the workman signs and dates the cards on the face, in a place provided for that purpose, and returns them to the gang foreman. If, for any reason such as lack of material, too short time, or the engine not dumped, the work reported cannot be attended to before the engine goes out, the foreman having the work card will make a note on the back of it to that effect, signing his name and date. This incomplete work card is then filed in the incomplete pigeon-hole, under the number of the engine. When the engine returns to the enginehouse the incomplete cards are taken from the pigeon-hole and handled as new cards. If the work has been done at the other end of the run the card is signed and handled in the usual manner.

NEW YORK CENTRAL LINES   FORM 2668. S. 9657. 200m. 8-08. (GHS 85112)

LOCOMOTIVE WORK CARD.   No.................

Eng. No.	Eng'r........or Insp........	Place and Date

....

....

....

Work Performed by	Date

ENGINEHOUSE WORK REPORT CARD.

Where wheels have been reported to be examined and it has been decided that they need not be changed, the enginehouse and

REMARKS—Why Not Done	Foreman	Date

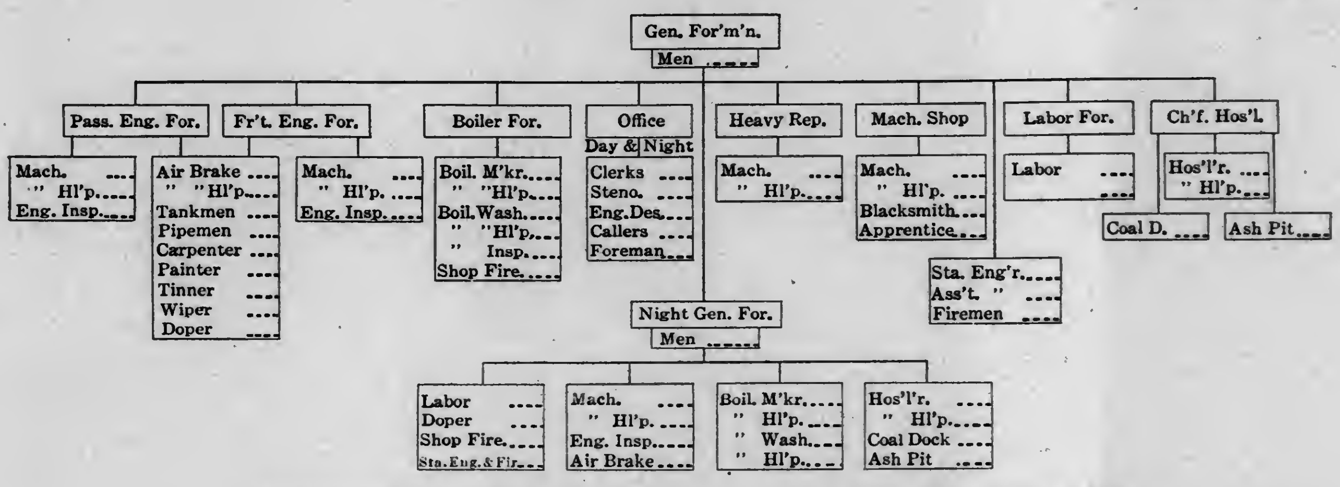
BACK OF ENGINEHOUSE WORK REPORT CARD.

gang foremen jointly inspect the wheels before they are allowed to go out. If it is decided to let them run both men sign the back of the card to the effect that, in their opinion, the wheels are in condition to run.

A distinction is made between cards for work which, upon inspection by the gang foreman, is found to be in good condition and cards for work, which, although necessary to be done, could not be finished before the engine left the house. Cards of the first class refer to work which, in the judgment of the engine foreman, is in good condition and need not be done. These cards are signed on the face by the foreman, giving the date, and stating that the work reported was not necessary. They are then filed in the finished work pigeon-hole. Cards of the second class are for work to be attended to on the return of the engine and these should be signed and dated on the back with a brief ex-

Organization Chart and Labor Cost Sheet.
Lake Shore and Michigan Southern Ry.
------------ Roundhouse.

Date—Mo. ------- Year.----



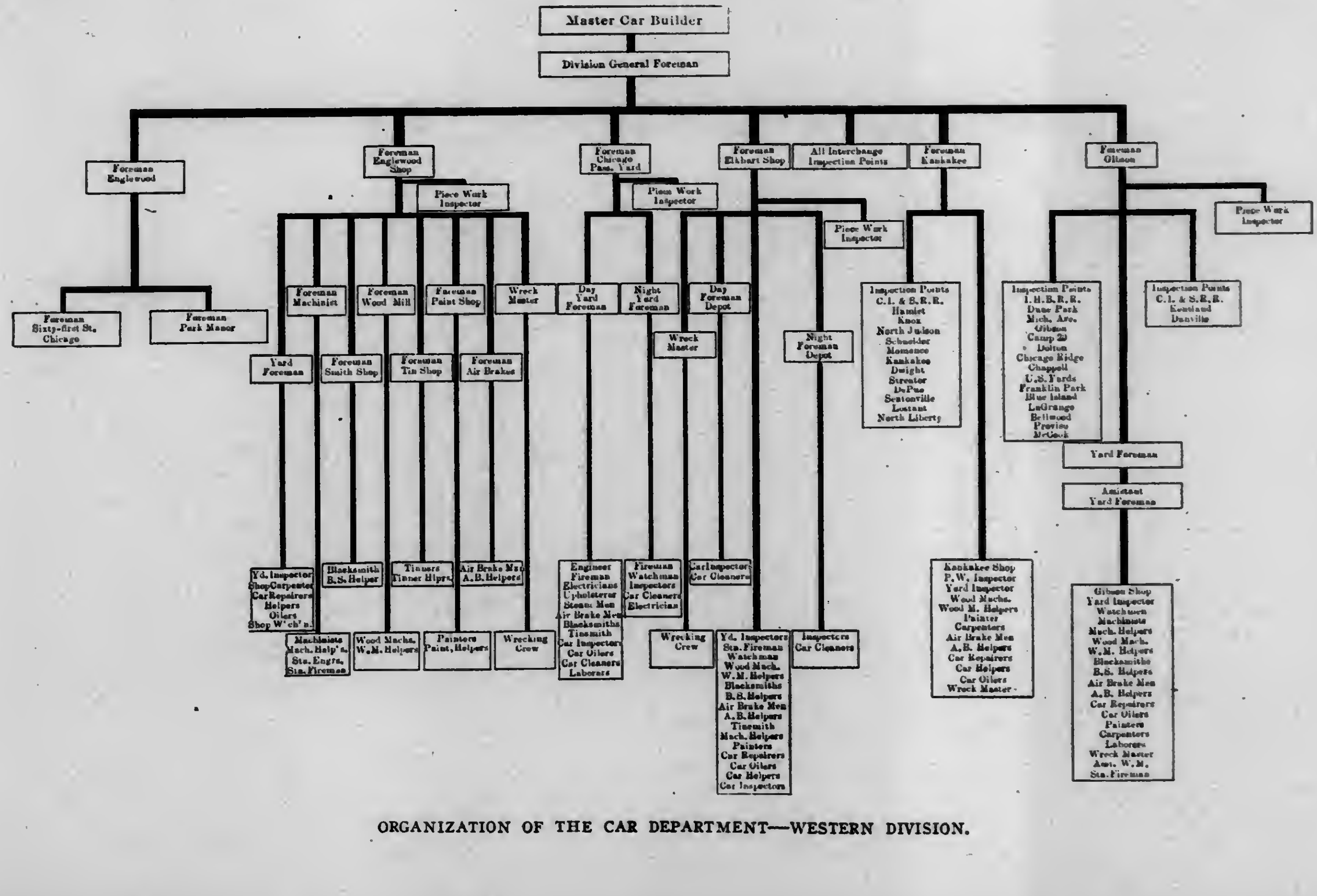
Average Daily Number of Mechanics	--------		Average Daily Labor Cost of R.H.	---------
" " " " Boiler Makers	--------		" " " " " Coal Dock	---------
" " " " Helpers	--------		Monthly " " " R.H.	--------
" " " " Office & Foremen	--------		" " " " Coal Dock	--------
" " " " Laborers	-------			
" " " " Coal-men	-------			
" " " " Ash- "	-------		Daily Number of Engines Handled	---------
Total " " " Men Employed	-------			

ENGINEHOUSE ORGANIZATION CHART AND LABOR COST SHEET.

planation of why the work was not done before the engine left the house.

The gang foreman returns all completed cards when the work is finished. The incomplete cards are turned in when the engine leaves the house, or at the close of the work periods. Incomplete cards for engines still in the house are turned over to the incoming gang foreman at the work office. At the close of the month all finished work cards are tied up in bunches, according to the engine numbers, and sent to the master mechanic's office, where they are filed.

Occasionally some one is detailed from the master mechanic's office to visit the enginehouses and check up the file cases with the work books. The checking of these cases show that very few of the cards are lost or misplaced. This is especially true, since the men have learned that missing cards will be traced and an explanation required. An important advantage of the work card file case is that it enables the enginehouse foreman to promptly and intelligently regulate his forces. The unfinished work, being always in sight in the case, can be checked quickly and enables him to determine whether each class of work is ahead or behind.



ORGANIZATION OF THE CAR DEPARTMENT—WESTERN DIVISION.

Organization Chart and Labor Cost Sheet.

Each month an organization chart and labor cost sheet, similar to the one shown in the illustration, is made out by each enginehouse foreman and forwarded to the master mechanic's office. This sheet shows the number of men engaged in each class of work, both day and night; the average daily cost of operating the enginehouse, also the coal dock; and the average number of engines handled daily. It is thus possible to compare the operation and efficiency of the enginehouses month by month.

If it is found by examination of the work report case that one line of work is falling behind, it may be seen at a glance just how many men are in the gang and the necessity for adjustment. The sheet not only gives the master mechanic valuable information, by which he can check the operation of each enginehouse, but the general foreman, and the foremen who assist him in compiling it are encouraged to observe and study the conditions more closely and to handle their forces to better advantage.

Car Department Organization.

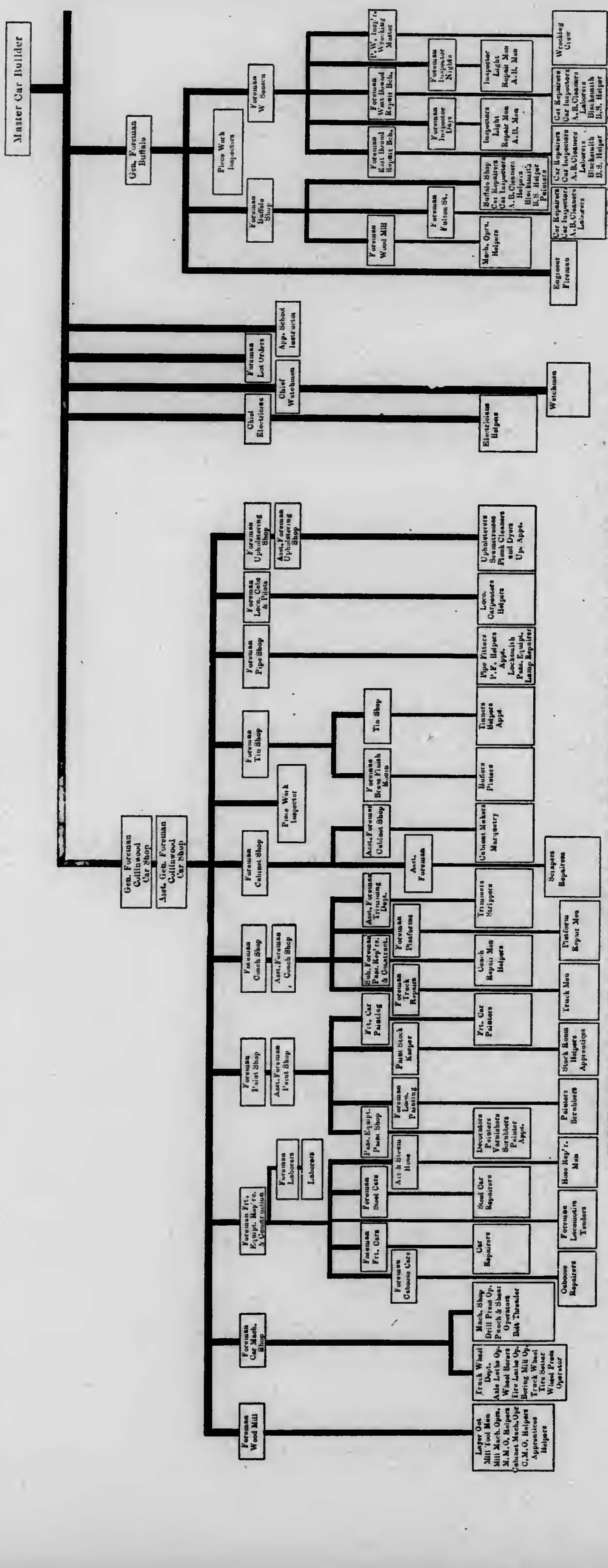
The car department is divided at Toledo: Toledo and points east are under the jurisdiction of the master car builder at Collinwood, and all points west of Toledo are under the jurisdiction of the master car builder at Englewood. The master car builder of the Eastern division has under his jurisdiction car shops at Collinwood, Air Line Junction, Ashtabula and Buffalo, in addition to repair yards at several other interchange points.

The organization of the car shop at Collinwood is clearly indicated in the diagram. The foreman of freight equipment repairs and construction has under him a foreman in charge of caboose repairs, foreman of wooden freight cars and a foreman of steel cars; the foreman of the paint shop has an assistant and the work is separated into four departments, including passenger equipment paint shop, freight car painting, locomotive painting and the paint storekeeper. While the foreman of locomotive painting is a member of the car department organization he, of course, is in intimate touch with the foreman of the locomotive shop and co-operates with him closely. The same thing is also true of the foreman of locomotive cabs and pilots, who reports directly to the general foreman of the car shop. The chief electrician, chief watchman, foreman of lot orders and apprentice school instructor at Collinwood are shown reporting direct to the master car builder; these men are also shown on the diagram of the superintendent of the Collinwoo[d] locomotive shops, and are responsible for wor[k] in both departments.

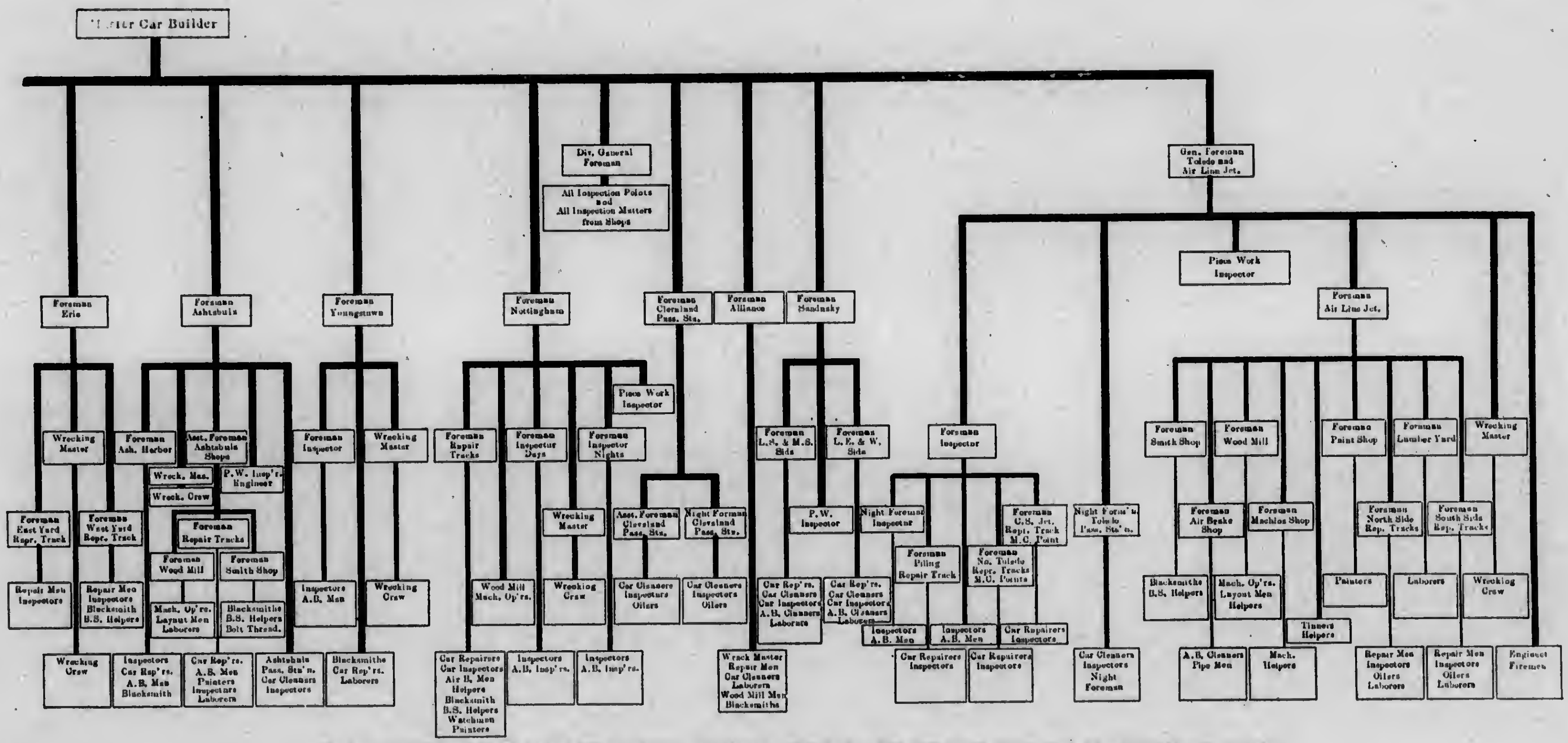
Little comment need be made on the rest o[f] the organization, as it is very clearly shown. There is a division general foreman who reports to the master car builder and has charge of all inspection points and inspection matters at the shops.

The master car builder of the Western division has shops at Englewood and Elkhart. There are a number of inspection points and repair points on this division and these are taken care of by the division general foreman.

Efficiency cards are made out by the various foremen to cover every employee in the car department. These cards are the same as used for



ORGANIZATION OF THE CAR DEPARTMENT—EASTERN DIVISION—SEE NEXT PAGE FOR REMAINDER OF CHART.



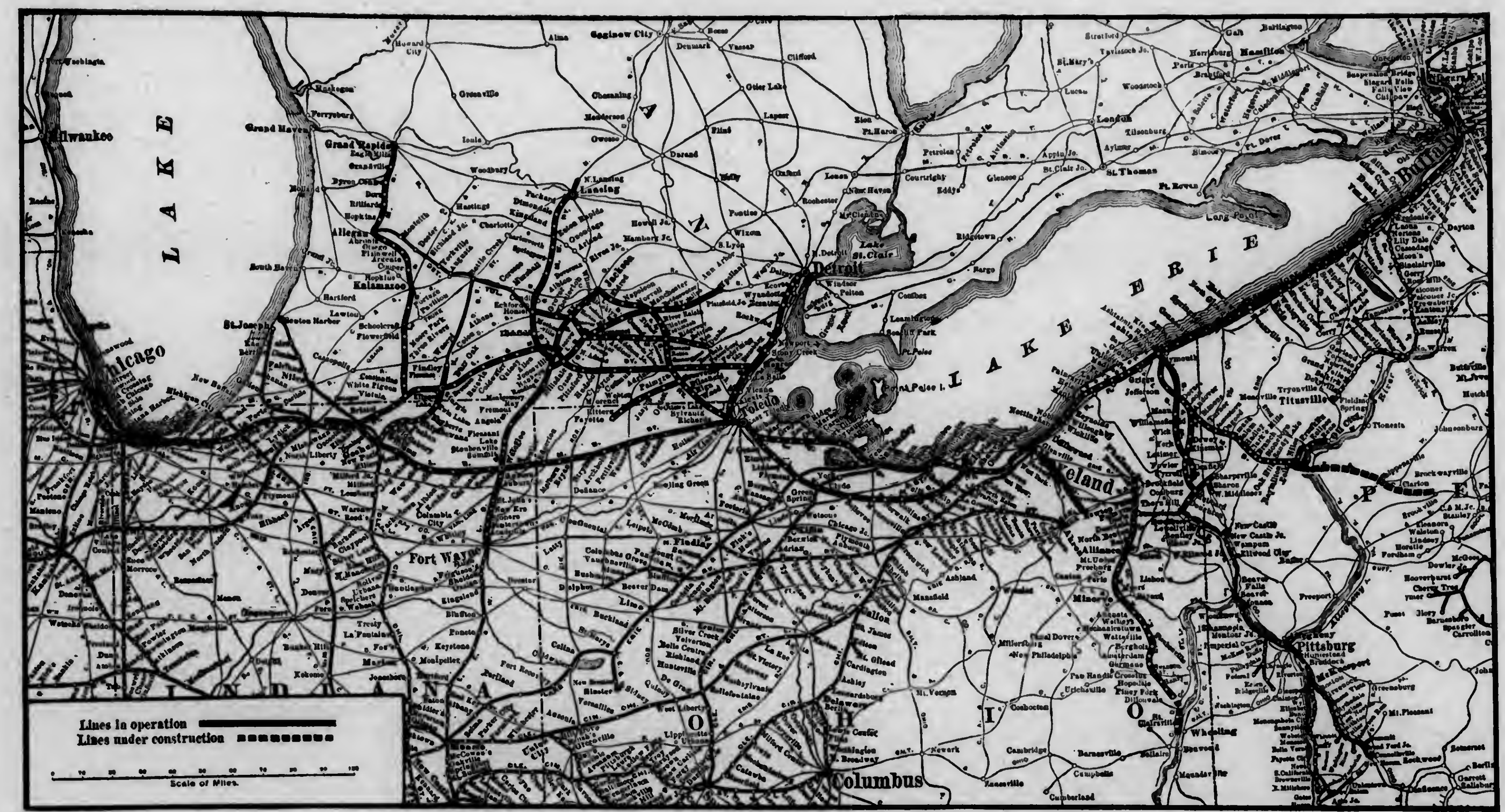
ORGANIZATION OF THE CAR DEPARTMENT—EASTERN DIVISION—SEE OPPOSITE PAGE FOR REMAINDER OF CHART.

Abstract from Passenger Car Failure Reports Showing Number of Failures and Miles Run per Failure, for Four Months This Year as Compared with a Year Ago.

		July.	August.	September.	October.
Miles run per passenger car failure	08	136,981	121,603	124,467	85,908
	07	90,484	62,595	49,277	50,369
Total number passenger car miles	08	4,794,335	4,864,117	4,720,435	4,553,125
	07	4,433,717	4,444,255	4,267,250	4,231,028
Number of passenger car failures	08	35	40	38	53
	07	49	71	82	84
Percentage of increase, miles run per car failure	08	51.3	94.2	152.5	70.5

all shop and enginehouse employees, as described in detail on pages 459 and 468.

A classified passenger car failure report is made showing all delays to trains of three minutes or more caused by any defect on a car in a passenger train. Due to the close study and analysis of these reports and the keying up of the entire organization, a remarkable improvement has been made during the past year, as may be seen from the accompanying table, which shows the miles run per passenger car failure, the total number of passenger car miles, the number of passenger car failures, and the percentage of increase in the miles per passenger car failure for July, August, September and October of this year, as compared to the same four months of last year.



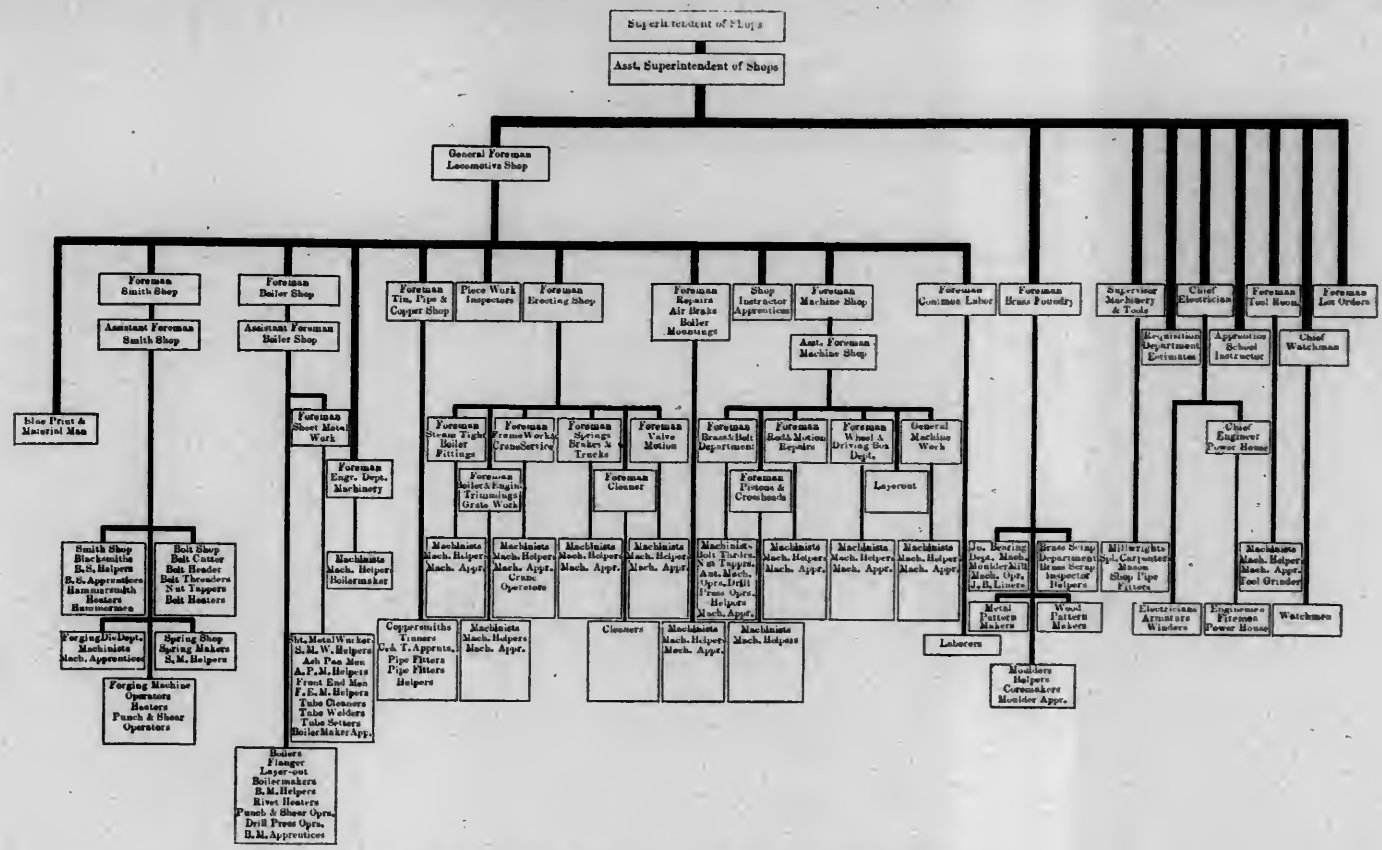
MAP SHOWING THE LAKE SHORE & MICHIGAN SOUTHERN RAILWAY.

The Lake Shore not only forms a splendidly equipped trunk line between Buffalo and Chicago, but its branches lie squarely in the main currents of freight movement. The main line between Buffalo and Chicago consists of 540.04 miles, having 311.75 miles of second track, 160.84 miles of third track, 117.69 miles of fourth track and 687.45 miles of siding. The total number of miles operated is 1,520.35, including branches, proprietary lines owned wholly by the company, and leased lines.

The average number of tons of revenue-earning freight carried per train mile during 1906 was 624.5, having increased to this from 318.5 in 1895. Reference to the Interstate Commerce Commission statistics for 1906 shows that the average for all the roads in the country during that year was 344.39 and the average for Group III, in which the Lake Shore is included, was 426.33. This exceptionally heavy train load indicates that the road must be in splendid physical condition and that its equipment must be first-class. The above figures are the more remarkable when it is considered that the main line between Chicago and Buffalo is 540 miles long, or only about 35½ per cent. of the mileage operated.

The passenger earnings for 1906 amounted to $8,715,702 and the earnings from mail and express, $3,390,004. The density of passenger traffic—the passengers carried one mile per mile of road—amounted to 277,840. The Interstate Commerce Commission statistics show that during 1906 this figure for all the roads in the country amounted to 114,529, while for Group III, in which the Lake Shore is included, it amounted to 120,794. The average number of passengers per train mile was 57.38 and the average number of miles one passenger was carried 58.70. For the entire country these figures amounted to 52.5 and 31.54, and in Group III to 45 and 38.64 respectively.

The rolling stock owned and leased by the company, as shown by the last annual report, amounted to 830 locomotives, 640 passenger cars, 40,891 freight cars and 1,673 company service cars.



ORGANIZATION OF THE COLLINWOOD LOCOMOTIVE SHOPS.

COLLINWOOD LOCOMOTIVE SHOPS.

Referring to the Collinwood locomotive shop organization diagram it will be seen that the direct line of authority extends from the superintendent of shops to the assistant superintendent of shops and to the various heads of departments.

This line of authority is carefully followed; all orders to the shops are issued over the signature of the assistant superintendent of shops, though many of these orders may be dictated by the superintendent of shops. All communications are addressed to the immediate superior, *i.e.*, the erecting or machine foreman will address the general foreman and the general foreman the assistant superintendent of shops. As the superintendent of shops and assistant superintendent of shops have adjoining offices and the same chief clerk, it is not necessary for them to write letters to one another.

It will be noted that the general foreman's organization consists practically of those responsible for locomotive output, except for the car department blacksmith shop, engineering department machinery repairs and the manufacturing departments in the machine and the tin department.

The blue print and material man is an experienced draftsman and shop man. The blueprints in this department are filed with the same system as in the mechanical engineer's office and are issued on shop checks. The blue print man also assists the general foreman in ordering and checking standard material, working in harmony with the shop chief draftsman of the mechanical engineer's staff.

The foreman of the smith shop, with his assistant, is in charge of the blacksmith shop, the bolt making department, spring department and forging machines. They are also in charge of the forging die department, including the making and repairing of dies for the forging machines, bulldozers and bolt headers. The general foreman of the locomotive shop is the employing officer of the foreman of the smith shop, although the smith shop foreman is responsible to the general foreman of the car department for the satisfactory performance of car department blacksmith work and will recognize regular orders for car department repairs direct, without coming through the general foreman of the locomotive shop.

In like manner the general foreman of the locomotive shop is responsible for locomotive painting, although the foreman painter of the master car builder's organization is the employing officer of the locomotive shop foreman of painting.

The foreman of engineering department machinery is responsible for repairs to steam shovels, stationary boilers, pile drivers, wreckers, etc.

The foreman of the tin, pipe and copper shop and the piecework inspectors report direct to the general foreman.

In studying the diagram of the foreman of the erecting shop, it will be seen that his organization is arranged to correspond with the organization in the machine shop; each gang foreman is in charge of a certain class of repairs on locomotives. To illustrate, the foreman of frame work and crane service is responsible for this work on all engines on the erecting floor. All work performed by the main crane is under his direction, thus gaining the greatest efficiency from the crane. In the fitting of shoes and wedges it is not possible for these parts for three engines to be delivered to the machine shop foreman at the same hour of the day, as these parts on each engine are repaired by the same men and in the order scheduled.

The stripping of locomotives is performed by specialists under the direction of the regular gang foreman. This makes each gang foreman directly responsible for the unnecessary stripping or taking down of parts not called for on the work report, or for the breaking of parts while stripping. While the work is being stripped it is placed in metal baskets which are taken to the lye vat, cleaned and distributed to the proper departments for repairs.

At the center of erecting shop a special bulletin board is placed to show engines scheduled out during the current week by days. Where two or more engines are out the same day they go in the order marked.

The foreman of the air brake department reports to the general foreman. This department repairs all boiler mountings, including steam gauges, injectors, lubricators, etc., for Collinwood locomotive shop; also similar parts for the enginehouses under the master mechanic's jurisdiction.

The shop instructor of apprentices is a practical mechanic and

capable of operating all machines in the machine shop. He devotes most of his time to the instruction of machine apprentices. The time devoted to any one individual is determined by the experience of the apprentice, and the importance of the operation. The shop instructor also keeps a complete record of each apprentice.

The machine shop organization, as stated before, is arranged similar to the erecting shop, and will be understood from the diagram. Each gang or department is provided with a bulletin board with the days of the week in the first or left-hand vertical column. In the column to the right is shown the engine numbers, the parts of which must be repaired and delivered to the erecting shop on each day. When the parts are not delivered on time, responsibility for the delay is placed.

The foreman of common labor has charge of all common laborers.

The superintendent of the brass foundry has supervision over the brass foundry and pattern makers. All waste products of white metals, foundry cinders, skimmings, brass turnings, etc., are turned over to this department, where the good material is separated from the waste. The superintendent of the brass foundry is also in charge of the journal bearing department. All second-hand journal bearings are shipped to this department; the linings are removed, the bearings carefully inspected and those that pass are re-lined and again placed in service. The brass scrap is thoroughly inspected and material that is good for further use is sent to the machine shop, repaired and again placed in service. All white metals are mixed and properly prepared and samples are taken and analyzed by the chemist and engineer of tests to see that they conform to the specifications.

The supervisor of machinery and tools is responsible for repairs to all the machinery and to the shop piping in the Collinwood locomotive and car departments.

The chief electrician is in charge of electric power and lighting of the entire Collinwood plant.

The apprentice school instructor is responsible for the instruction of apprentices in the school room.

The foreman of the tool room is in charge of the tool room and small tools throughout the plant, including air motors, air hammers; also the grinding and supplying of all tools for machines.

The chief watchman is responsible for the proper protection and patrolling of the Collinwood locomotive and car department buildings and grounds, also the enginehouse and adjacent territory.

ORGANIZATION CHARTS.

The making of the organization charts, considered in the previous sections of this article, often discloses a weakness in the form of organization, making it possible to simplify it and eliminate any conflict of authority. The charts are not of prime importance, but they are helpful because they show at a glance the jurisdiction of any official or foreman, and the proper route by which matters are to be taken up with him.

The important feature of any organization is to have a definite and exact understanding of the duties of every man in it and to know just how far the duties of each extend.

The making of these diagrams will direct attention to the logical arrangements; after all, the form of organization should be based strictly on common sense, the object being to accomplish the best results with the least possible expenditure of energy and the smallest amount of red tape.

EFFICIENCY CARD SYSTEM.

The efficiency card system used in connection with the shop and enginehouse employees is somewhat more elaborate than that used in the master mechanic's department for the locomotive firemen, as described on page 459. Several typical efficiency cards are shown in the illustrations. It is, of course, necessary to have concise and standard definitions for each of the items, and in order that each foreman making out the cards may have a like understanding of the definition of the words, they have been carefully prepared and are as follows:

EDUCATION: Mental and moral training.
SPECIAL KNOWLEDGE:
HONESTY: Upright disposition or conduct.
MORALITY: Accord with the rules of right conduct.
TEMPERANCE: Moderation.
TACT: Ability to do or say what is best for the intended effect.
RESOURCE: Good at devising expedients.
RELIANCE: Sure dependence.
FORESIGHT: The act or power of foreseeing.
APPEARANCE: Outward look or aspect.
MEMORY: Mental hold on the past.
ENERGY: Active, effective.
INITIATIVE: The ability or disposition to take the lead.
PERSISTENCE: Steady or firm adherence to, or continuance in a state, course of action, or pursuit that has been entered upon.
ASSERTIVENESS: Affirming confidently; positive.
DISCIPLINE: To teach rules and practice and accustom to order and subordination.
PROMPTNESS: Quickness of decision or action.
ACCURACY: Correctness.
SYSTEM: Regular method or order.
ORGANIZATION: A systematic and regulated whole.
EXECUTIVE ABILITY: Ability to carry into effect in a practical manner.

These cards are made out by the line officers for each of their foremen and sent direct to the office of the superintendent motive power, where they are reviewed and placed on file. The foremen make out cards for each employee under them and these are reviewed and placed on file in the office of the line officer. It is evident that in order to have these records accurate the foreman must carefully study and observe each individual under him. Each foreman is supplied with just enough cards, and he does not keep any copy of his reports. He is thus forced to observe the men more closely in order that future reports may show accurately any improvement or falling off from the former ones.

This system has been in effect, in some of the branches of the department, for three years and has shown good results. First-class men with qualities which make them eligible for promotion, are in this way discovered and may be developed along the proper lines. The foremen are broadened and developed* by this study, and each one is encouraged to analyze more closely his work, disposition and character. Every man understands that these records are being kept and that they are studied by the men at the head of the department; they are thus encouraged to improve and better themselves. It is not unusual to make a brief notation at the bottom of the cards; thus—"should make a good man" appears on the card of one of the young men who is low in qualities which can be developed by application on his part; "will improve in time" and "good material" are also among the notations on some of the cards.

THE CLERICAL FORCE.

Duties of the Chief Clerk, or Secretary.

(This section is condensed from an outline which was prepared for distribution among the chief clerks in the mechanical department.)

The work of the secretary, or chief clerk, to a railroad official may be divided into four parts, as follows:

First, general correspondence, which occupies the greater part of his time.

Second, consideration of the larger details of the office, such as listening to and deciding important questions submitted by subordinates, analyzing reports and improving the organization.

Third, receiving callers.

Fourth, general duties.

First—Correspondence: The essentials in handling correspondence are familiarity with the subjects under discussion; regularity, punctuality, and carefulness. Too much emphasis cannot be placed on the necessity for thoroughly familiarizing

* As an illustration of this the following incident is cited. One of the foremen did not fill in all of the items on some of the cards. When questioned by his superior he said that he did not know the men well enough to express an opinion. The cards were returned to him and he was told to fill them in completely. He should be able by talking with the men and sizing them up closely to at least give an opinion on the various items. Before the next set of cards were received he would have time to study any questionable points and to revise his estimates. He was frankly told that in order to be promoted to a position where he would have to hire men he must cultivate the habit of sizing them up quickly and accurately.

FORM 2567 S. 195. 10m. 9-08. W&S

NAME O'Brien, John
EMPLOYED AT Elkhart
AS Machinist

	VERY GOOD	GOOD	MEDIUM	POOR
EDUCATION			●	
SPECIAL KNOWLEDGE	●			
EXPERIENCE	●			
HONESTY	●			
MORALITY	●			
TEMPERANCE	●			
TACT	●			
RESOURCE	●			
RELIANCE	●			
FORESIGHT	●			
APPEARANCE	●			
MEMORY		●		
ENERGY	●			
INITIATIVE		●		
PERSISTENCE	●			
ASSERTIVENESS		●		
DISCIPLINE	●			
PROMPTNESS	●			
ACCURACY		●		
SYSTEM	●			
ORGANIZATION	●			
EXECUTIVE ABILITY	●			

INDIVIDUAL EFFICIENCY CARD—A GOOD MAN.

oneself with all the work, as more time is wasted in handling unfamiliar subjects than in any other way. The chief clerk should be capable of handling, with a few pointers, almost any subject which might come up in the regular course of business. His letters should be clear and concise and yet of sufficient length to explain fully the subjects treated.

FORM 2567 S. 195. 10m. 9-08. W&S

NAME Willson, Paddenhead
EMPLOYED AT Boiler maker
AS Astabula

	VERY GOOD	GOOD	MEDIUM	POOR
EDUCATION	●			
SPECIAL KNOWLEDGE		●		
EXPERIENCE		●		
HONESTY	●			
MORALITY	●			
TEMPERANCE	●			
TACT			●	
RESOURCE			●	
RELIANCE		●		
FORESIGHT			●	
APPEARANCE	●			
MEMORY		●		
ENERGY		●		
INITIATIVE			●	
PERSISTENCE			●	
ASSERTIVENESS			●	
DISCIPLINE		●		
PROMPTNESS		●		
ACCURACY		●		
SYSTEM		●		
ORGANIZATION		●		
EXECUTIVE ABILITY		●		

INDIVIDUAL EFFICIENCY CARD—A GOOD MAN, BUT WOULD MAKE A POOR FOREMAN.

Up-to-date practice is for the chief clerk to go through the correspondence with his employer each morning and make such notations as he thinks necessary in order to properly reply to the letters. Correspondence which is likely to be desired in connection with any of the letters should be attached before submitting them. He should make sure before submitting either questions or statements that they have been very carefully prepared and that he has a full understanding of their meaning. He is thus in position to call attention to any unusual conditions and to make pertinent suggestions.

Second—Handling of Office Details: The first discovery that a man usually makes on receiving a new appointment is that if the day consisted of forty-eight instead of twenty-four hours, and every hour was devoted to office work, there would not be enough time to meet all the demands. It is therefore essential

FORM 2567 S. 195. 10m. 9-08. W&S

NAME Zelinypski, Frank
EMPLOYED AT Moulder Apprentice
AS Collinwood

	VERY GOOD	GOOD	MEDIUM	POOR
EDUCATION				● †
SPECIAL KNOWLEDGE				● †
EXPERIENCE			†	●
HONESTY		●		†
MORALITY			●	†
TEMPERANCE			● †	
TACT				● †
RESOURCE			†	●
RELIANCE			●	†
FORESIGHT				●
APPEARANCE		●	†	
MEMORY		●	†	†
ENERGY				● †
INITIATIVE				● †
PERSISTENCE			● †	
ASSERTIVENESS			● †	
DISCIPLINE		●		†
PROMPTNESS			●	†
ACCURACY				● †
SYSTEM			●	†
ORGANIZATION				● †
EXECUTIVE ABILITY				● †

● = MARKS GIVEN BY SHOP INSTRUCTOR
† = " " " DRAWING INSTRUCTOR

A COMBINATION OF TWO EFFICIENCY CARDS MADE OUT FOR AN APPRENTICE BY THE SHOP AND DRAWING INSTRUCTORS, SHOWING HOW CLOSELY THE MARKINGS AGREE IN GENERAL, ALTHOUGH THE CARDS WERE MADE OUT INDEPENDENTLY, AND WITHOUT CONFERENCE.

to economize time as the most precious commodity. This may best be done by adhering closely to the following maxims:

Subordinates should be chosen carefully and should be men who can be relied upon.

Harmony and good feeling are essential in all well regulated organizations and the conduct of the chief clerk is of prime importance in the building up of the organization.

He must be fully conversant with all the details of the work, but must not concern himself with details which his subordinates are just as well able to deal with as he is; he should reserve himself for such matters of moment as they are not competent to decide without his authority and experience.

Before any question is submitted to him for decision he should insist upon having all the facts placed before him, so that it will not be necessary for him to apply his mind to it a second time, but may decide it at once and for all.

He should not attempt to do two or more things at once. The

man in authority, who is constantly surrounded by a throng of subordinates and striving to meet all their demands at once, does not accomplish as much work as the one who steadily concentrates himself on one thing at a time, never wasting a moment and never getting flurried or hurried.

He should be contented and should not have his mind preoccupied by his own worries or fancied grievances. It is impossible to work to advantage under such conditions.

The duties of each member of the organization should be clearly defined, so that responsibility may be properly placed. The organization should be studied carefully in order to cut out all lost motion, friction and unnecessary work.

In order to develop each individual to the fullest extent it is necessary to increase his responsibility from time to time, as the work will permit. Initiative must be encouraged on the part of subordinates and all suggestions received from them should be treated with deference and interest.

Subordinates should be carefully studied and in a quiet way should be coached to assist them in improving weak points.

Third—Receiving Callers: The employer is often judged by the conduct of his secretary or chief clerk. One of the most important duties of a chief clerk is at all times to receive callers with courtesy; he should be readily accessible. As a rule all callers insist upon seeing the head of the department, and it is difficult to get them to even disclose the nature of their business to another person. The ideal chief clerk will handle them diplomatically so that, if necessary, they will leave the office without consuming too much of the time of his superior, and yet feel that they have been well taken care of.

Fourth—General Duties: The chief clerk must, of course, have the complete confidence of his employer, and to retain this it is necessary that all details be handled regularly, promptly and carefully. He should see that the rulings of the executive head of the department are promptly and properly promulgated and that they are followed by the other members of the organization.

The chief clerk to the superintendent of motive power, at Cleveland, holds stated meetings with the chief clerks of the various division officers, the object of these meetings being to gain a better understanding of their duties and to keep them in close touch with the central organization.

The chief clerk to the superintendent motive power has jurisdiction over the entire clerical force of the motive power department.

THE CLIPPING BUREAU.

A clipping bureau has been established as a permanent feature and in the campaign of education for building up the organization it played a prominent part. All the technical papers and magazines are carefully examined by a man especially qualified and articles of interest to any official or foreman are marked and a page reference made on the outside cover. This is especially true of articles in any way relating to organization problems. The papers are circulated and when finally returned to the office the articles are clipped and filed under their respective subjects for reference. Extracts of important articles are often reprinted or extra copies of the paper in which they appear are obtained and sent to the various officials. In some instances they are asked to give a written opinion of the article in question.

The idea of efficiency cards was discovered in this manner, a like system being in use in a large department store, the handling of which was described in one of the journals. Much of the subject matter in the article on duties of the chief clerk was collected from the clipping file.

In addition to the general library in the office of the superintendent motive power, branch libraries of well chosen technical books have been established at division headquarters, the idea being that books of this character are just as important as good machine tools or other equipment.

THREE-PHASE ELECTRIC LOCOMOTIVE.

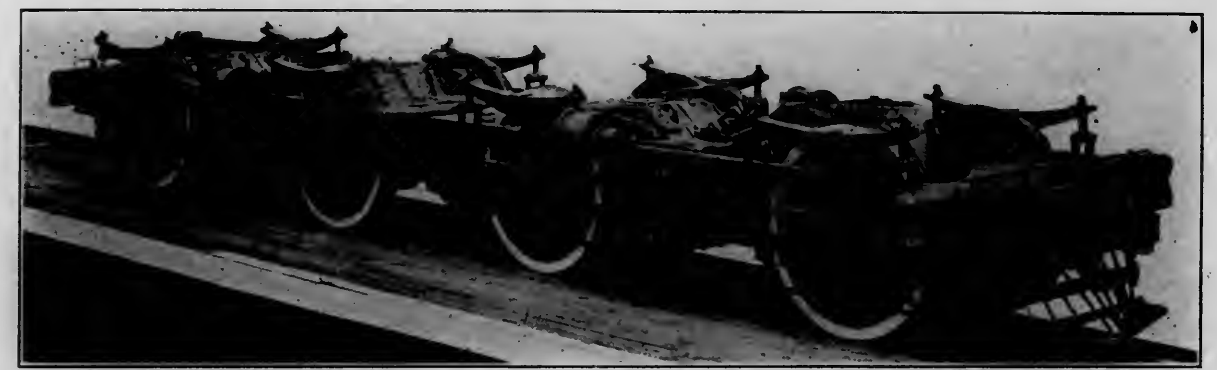
GREAT NORTHERN RAILWAY.

The first electric locomotives to operate under steam railroad conditions, using three-phase alternating current for power, have recently been delivered to the Great Northern Railway by the American Locomotive and General Electric Companies and will be used for hauling freight and passenger traffic through the Cascade tunnel. There are four locomotives or units in the order.

The Cascade tunnel is somewhat less than three miles in length and is so located as to forbid the introduction of ventilating shafts, which, taken in connection with the fact that there is a 1.7 grade in one direction through it, makes steam locomotive operation very undesirable, particularly in passenger traffic. Electric operation, however, overcomes this objection perfectly and, although electric locomotives will be used simply through the tunnel at present, plans are being formulated for also electrically operating several other grades in the vicinity.

The locomotives, as can be seen in the illustration, are of the double truck, four driver type and weigh 230,000 lbs. They differ from previous locomotives of this wheel arrangement, however, in the fact that the two trucks are connected to each other in the center and incorporate the draft gear and couplers within their frame. In this way the whole pulling stress is delivered directly through the truck frames and does not come upon the cab underframe at all. The use of the articulated connection, of course, alters the relative positions of the two center pins in rounding curves, and it has been necessary to arrange for a longitudinal movement at one of them, which, since there is little stress on the pin, is very easily taken care of.

Four 400 h.p. three-phase induction motors are provided, each driving one pair of driving wheels through a double



RUNNING GEAR—GREAT NORTHERN THREE-PHASE ELECTRIC LOCOMOTIVE.

set of spur gearing, the secondary circuit to each motor being mounted on a shaft which carries a pinion gear at each end. These pinions mesh with gear bands shrunk on an extension of the driving wheel centers, the gear ratio being 1 to 4.28. The motors are wound for eight poles and when operated at 25 cycles have a synchronous speed of 375 r.p.m., which gives a locomotive speed of about 15½ miles per hour. The trolley voltage will be at 6,600 volts, which is transformed to 500 volts for use at the motors.

The truck frames are of cast steel and are made very heavy

THREE-PHASE ELECTRIC LOCOMOTIVE—GREAT NORTHERN RY.

and substantial. There was no desire to save weight at any point, as it was even necessary to add extra ballast to the locomotive to obtain sufficient adhesion. The frames of the two trucks are interchangeable, although the equalizing systems are different. Both trucks carry semi-elliptical springs over the journals, which in one case are equalized together on one side of the truck, and in the other are equalized across the trucks, the two springs over the journals on the same axle being equalized together.

The arrangement of the apparatus and controlling devices within the cab of the locomotive has been made as simple as possible. The transformers, contactors, blowers, air compressors, etc., are placed within a fireproof compartment located in the center of the cab, having a wide passage-way on all sides. The engineer's controller and indicating apparatus are located in the usual place in the right-hand corner on either end. The transformers are of the air-cooled, two-coil type, a motor-driven centrifugal blower being provided, which gives low pressure air for cooling the transformers, contactors and motors. It might be mentioned that the designers of the electrical features of this locomotive were not hampered by a desire to obtain great economy, since a liberal supply of power is obtained from a hydro-electric plant located on the Wenatchee River, about 30 miles away. The current is transmitted at 30,000 volts, and stepped down by transformers at the mouth of the tunnel to 6,600 volts. Under those conditions the electrical equipment could be made of the simplest and most substantial type.

As will be noted in the illustration, the locomotive is equipped with four trolleys, two of which will be used for operation in either direction, the rail being employed as a third conductor. One of the advantages of the three-phase equipment is the tendency to operate at a constant speed, which in this case is about 15 miles per hour. In going down grade this speed is maintained by the regenerative tendency of the motors, which will return a certain amount of energy to the supply system.

The locomotives under test have shown themselves to be capable of exerting three times the guaranteed full load running torque at any speed from a standstill to within a few per cent. of synchronism.

They have the following general dimensions:

Total weight	230,000 lbs.
Length over couplers	44 ft. 2 in.
Length over cab	40 ft. 1¾ in.
Height of cab	14 ft.
Width over all	10 ft.
Total wheel base	31 ft. 9 in.
Rigid wheel base	11 ft.

INTERNATIONAL RAILWAY FUEL ASSOCIATION.

On November 20, a meeting was held in the parlors of the Auditorium Annex Hotel, Chicago, for the purpose of forming a fuel association for the railroads of the United States, Canada and Mexico. Forty-one persons were present. It was decided to call it The International Railway Fuel Association. A constitution and by-laws were adopted; the first annual meeting will be held in June, 1909.

The object of the Association will be to advance the interests of the employer by recommending the adoption of the best methods of purchasing, inspecting, weighing, distributing, handling and accounting for fuel. The constitution is so framed as to include in the Association as associate members, officials or representatives of concerns engaged in the production of fuel, either coal or oil, fuel handling devices and equipment, weighing and fuel consuming or labor saving devices.

The following officers were elected: President, Eugene McAuliffe, general fuel agent, Rock Island-Frisco Lines, Chicago; first vice-president, Thomas Britt, general fuel agent, Canadian Pacific Ry., Montreal; second vice-president, G. R. Ingersoll, purchasing agent, L. S. & M. S. Ry., Cleveland; secretary, D. B. Sebastian, fuel supervisor, C. & E. I. R. R. and E. & T. H. R. R., 327 La Salle street station, Chicago; treasurer, J. McManamy, road foreman of engines, Pere Marquette Ry., Grand Rapids, Mich.; executive committee for two years, C. F. Richardson, fuel agent, St. L. & S. F. R. R., St. Louis; S. L. Yerkes, fuel agent, Queen & Crescent System, Lexington, Ky.; J. H. Hibben, fuel agent, M. K. & T. R. R., Parsons, Kan.

M. M. AND M. C. B. CONVENTIONS.

The executive committees of the Railway Master Mechanics' and the Master Car Builders' Associations met in New York City, on November 20, and decided to hold the 1909 conventions in Atlantic City, N. J., June 16 to 25; the Master Mechanics' convention to be held first.

The executive committee of the Railway Supply Manufacturers' Association met on the same day and decided upon Young's Million Dollar Pier for the place of the convention meetings and the exhibits.

At the request of the executive committees of the M. M. and the M. C. B. Associations, action was taken by the executive committee of the Railway Supply Manufacturers' Association forbidding the distribution of souvenirs at the conventions.

Application for exhibit space should be made to Earl G. Smith, secretary of the Railway Supply Manufacturers' Assn., 345 Old Colony Building, Chicago.

man in authority, who is constantly surrounded by a throng of subordinates and striving to meet all their demands at once, does not accomplish as much work as the one who steadily concentrates himself on one thing at a time, never wasting a moment and never getting flurried or hurried.

He should be contented and should not have his mind preoccupied by his own worries or fancied grievances. It is impossible to work to advantage under such conditions.

The duties of each member of the organization should be clearly defined, so that responsibility may be properly placed. The organization should be studied carefully in order to cut out all lost motion, friction and unnecessary work.

In order to develop each individual to the fullest extent it is necessary to increase his responsibility from time to time, as the work will permit. Initiative must be encouraged on the part of subordinates and all suggestions received from them should be treated with deference and interest.

Subordinates should be carefully studied and in a quiet way should be coached to assist them in improving weak points.

Third—Receiving Callers: The employer is often judged by the conduct of his secretary or chief clerk. One of the most important duties of a chief clerk is at all times to receive callers with courtesy: he should be readily accessible. As a rule all callers insist upon seeing the head of the department, and it is difficult to get them to even disclose the nature of their business to another person. The ideal chief clerk will handle them diplomatically so that, if necessary, they will leave the office without consuming too much of the time of his superior, and yet feel that they have been well taken care of.

Fourth—General Duties: The chief clerk must, of course, have the complete confidence of his employer, and to retain this it is necessary that all details be handled regularly, promptly and carefully. He should see that the rulings of the executive head of the department are promptly and properly promulgated and that they are followed by the other members of the organization.

The chief clerk to the superintendent of motive power, at Cleveland, holds stated meetings with the chief clerks of the various division officers, the object of these meetings being to gain a better understanding of their duties and to keep them in close touch with the central organization.

The chief clerk to the superintendent motive power has jurisdiction over the entire clerical force of the motive power department.

THE CLIPPING BUREAU.

A clipping bureau has been established as a permanent feature and in the campaign of education for building up the organization it played a prominent part. All the technical papers and magazines are carefully examined by a man especially qualified and articles of interest to any official or foreman are marked and a page reference made on the outside cover. This is especially true of articles in any way relating to organization problems. The papers are circulated and when finally returned to the office the articles are clipped and filed under their respective subjects for reference. Extracts of important articles are often reprinted or extra copies of the paper in which they appear are obtained and sent to the various officials. In some instances they are asked to give a written opinion of the article in question.

The idea of efficiency cards was discovered in this manner, a like system being in use in a large department store, the handling of which was described in one of the journals. Much of the subject matter in the article on duties of the chief clerk was collected from the clipping file.

In addition to the general library in the office of the superintendent motive power, branch libraries of well chosen technical books have been established at division headquarters, the idea being that books of this character are just as important as good machine tools or other equipment.

THREE-PHASE ELECTRIC LOCOMOTIVE.

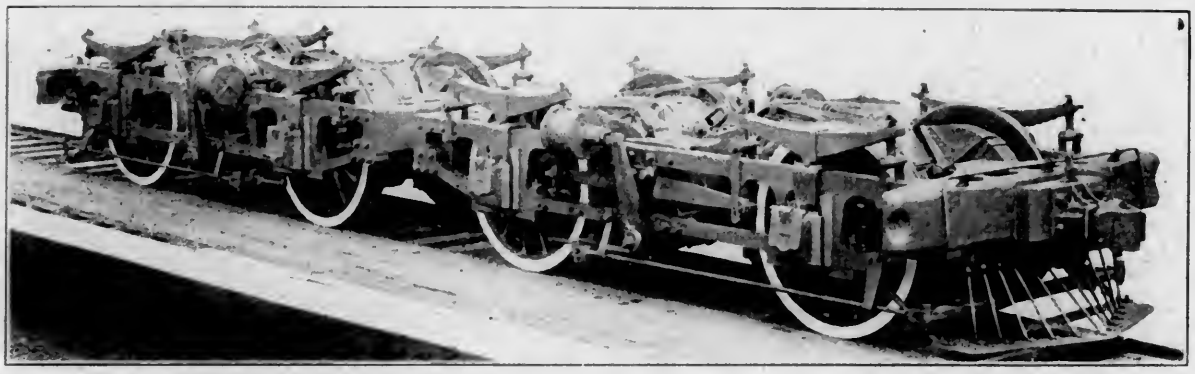
GREAT NORTHERN RAILWAY.

The first electric locomotives to operate under steam railroad conditions, using three-phase alternating current for power, have recently been delivered to the Great Northern Railway by the American Locomotive and General Electric Companies and will be used for hauling freight and passenger traffic through the Cascade tunnel. There are four locomotives or units in the order.

The Cascade tunnel is somewhat less than three miles in length and is so located as to forbid the introduction of ventilating shafts, which, taken in connection with the fact that there is a 1.7 grade in one direction through it, makes steam locomotive operation very undesirable, particularly in passenger traffic. Electric operation, however, overcomes this objection perfectly and, although electric locomotives will be used simply through the tunnel at present, plans are being formulated for also electrically operating several other grades in the vicinity.

The locomotives, as can be seen in the illustration, are of the double truck, four driver type and weigh 230,000 lbs. They differ from previous locomotives of this wheel arrangement, however, in the fact that the two trucks are connected to each other in the center and incorporate the draft gear and couplers within their frame. In this way the whole pulling stress is delivered directly through the truck frames and does not come upon the cab underframe at all. The use of the articulated connection, of course, alters the relative positions of the two center pins in rounding curves, and it has been necessary to arrange for a longitudinal movement at one of them, which, since there is little stress on the pin, is very easily taken care of.

Four 400 h.p. three-phase induction motors are provided, each driving one pair of driving wheels through a double set of spur gearing, the secondary circuit to each motor being mounted on a shaft which carries a pinion gear at each end. These pinions mesh with gear bands shrunk on an extension of the driving wheel centers, the gear ratio being 1 to 4.28. The motors are wound for eight poles and when operated at 25 cycles have a synchronous speed of 375 r.p.m., which gives a locomotive speed of about 15½ miles per hour. The trolley voltage will be at 6,600 volts, which is transformed to 500 volts for use at the motors.



RUNNING GEAR—GREAT NORTHERN THREE-PHASE ELECTRIC LOCOMOTIVE.

The truck frames are of cast steel and are made very heavy

THREE-PHASE ELECTRIC LOCOMOTIVE—GREAT NORTHERN RY.

and substantial. There was no desire to save weight at any point, as it was even necessary to add extra ballast to the locomotive to obtain sufficient adhesion. The frames of the two trucks are interchangeable, although the equalizing systems are different. Both trucks carry semi-elliptical springs over the journals, which in one case are equalized together on one side of the truck, and in the other are equalized across the trucks, the two springs over the journals on the same axle being equalized together.

The arrangement of the apparatus and controlling devices within the cab of the locomotive has been made as simple as possible. The transformers, contactors, blowers, air compressors, etc., are placed within a fireproof compartment located in the center of the cab, having a wide passage-way on all sides. The engineer's controller and indicating apparatus are located in the usual place in the right-hand corner on either end. The transformers are of the air-cooled, two-coil type, a motor-driven centrifugal blower being provided, which gives low pressure air for cooling the transformers, contactors and motors. It might be mentioned that the designers of the electrical features of this locomotive were not hampered by a desire to obtain great economy, since a liberal supply of power is obtained from a hydro-electric plant located on the Wenatchee River, about 30 miles away. The current is transmitted at 30,000 volts, and stepped down by transformers at the mouth of the tunnel to 6,000 volts. Under those conditions the electrical equipment could be made of the simplest and most substantial type.

As will be noted in the illustration, the locomotive is equipped with four trolleys, two of which will be used for operation in either direction, the rail being employed as a third conductor. One of the advantages of the three-phase equipment is the tendency to operate at a constant speed, which in this case is about 15 miles per hour. In going down grade this speed is maintained by the regenerative tendency of the motors, which will return a certain amount of energy to the supply system.

The locomotives under test have shown themselves to be capable of exerting three times the guaranteed full load running torque at any speed from a standstill to within a few per cent. of synchronism.

They have the following general dimensions:

Total weight	230,600 lbs.
Length over couplers	44 ft. 2 in.
Length over cab	40 ft. 1¾ in.
Height of cab	14 ft.
Width over all	10 ft.
Total wheel base	31 ft. 9 in.
Rigid wheel base	11 ft.

INTERNATIONAL RAILWAY FUEL ASSOCIATION.

On November 20, a meeting was held in the parlors of the Auditorium Annex Hotel, Chicago, for the purpose of forming a fuel association for the railroads of the United States, Canada and Mexico. Forty-one persons were present. It was decided to call it The International Railway Fuel Association. A constitution and by-laws were adopted; the first annual meeting will be held in June, 1909.

The object of the Association will be to advance the interests of the employer by recommending the adoption of the best methods of purchasing, inspecting, weighing, distributing, handling and accounting for fuel. The constitution is so framed as to include in the Association as associate members, officials or representatives of concerns engaged in the production of fuel, either coal or oil, fuel handling devices and equipment, weighing and fuel consuming or labor saving devices.

The following officers were elected: President, Eugene McAuliffe, general fuel agent, Rock Island-Frisco Lines, Chicago; first vice-president, Thomas Britt, general fuel agent, Canadian Pacific Ry., Montreal; second vice-president, G. R. Ingersoll, purchasing agent, L. S. & M. S. Ry., Cleveland; secretary, D. B. Sebastian, fuel supervisor, C. & E. I. R. R. and E. & T. H. R. R., 327 La Salle street station, Chicago; treasurer, J. McManamy, road foreman of engines, Pere Marquette Ry., Grand Rapids, Mich.; executive committee for two years, C. F. Richardson, fuel agent, St. L. & S. F. R. R., St. Louis; S. L. Yerkes, fuel agent, Queen & Crescent System, Lexington, Ky.; J. H. Hibben, fuel agent, M. K. & T. R. R., Parsons, Kan.

M. M. AND M. C. B. CONVENTIONS.

The executive committees of the Railway Master Mechanics' and the Master Car Builders' Associations met in New York City, on November 20, and decided to hold the 1909 conventions in Atlantic City, N. J., June 16 to 23; the Master Mechanics' convention to be held first.

The executive committee of the Railway Supply Manufacturers' Association met on the same day and decided upon Young's Million Dollar Pier for the place of the convention meetings and the exhibits.

At the request of the executive committees of the M. M. and the M. C. B. Associations, action was taken by the executive committee of the Railway Supply Manufacturers' Association forbidding the distribution of souvenirs at the conventions.

Application for exhibit space should be made to Earl G. Smith, secretary of the Railway Supply Manufacturers' Assn., 345 Old Colony Building, Chicago.

(Established 1832).

AMERICAN ENGINEER AND RAILROAD JOURNAL.

PUBLISHED MONTHLY

BY

R. M. VAN ARSDALE

140 NASSAU STREET, NEW YORK

J. S. BONSALL,
Business Manager.

R. V. WRIGHT, } Editors.
E. A. AVERILL, }

DECEMBER, 1908

Subscriptions.—*$2.00 a year for the United States and Canada; $2.50 a year to Foreign Countries embraced in the Universal Postal Union. Remit by Express Money Order, Draft or Post Office Order. Subscription for this paper will be received and copies kept for sale by the Post Office News Co., 217 Dearborn St., Chicago, Ill. Damrell & Upham, 283 Washington St., Boston, Mass. Philip Roeder, 307 North Fourth St., St. Louis, Mo. R. S. Davis & Co., 346 Fifth Ave., Pittsburg, Pa. Century News Co., 6 Third St., S. Minneapolis, Minn. W. Dawson & Sons, Ltd., Cannon St., Bream's Buildings, London, E. C., England.*

Advertisements.—*Nothing will be inserted in this journal for pay,* EXCEPT IN THE ADVERTISING PAGES. *The reading pages will contain only such matter as we consider of interest to our readers.*

Contributions.—*Articles relating to Motive Power Department problems, including the design, construction, maintenance and operation of rolling stock, also of shops and roundhouses and their equipment are desired. Also early notices of official changes, and additions of new equipment for the road or the shop, by purchase or construction.*

A CHAT WITH THE EDITORS.

As the year draws to a close it may not be unprofitable to look backward and study the changes in policy and the improvements which have been made in our columns during the past year or two, with a view of forecasting the work of the year which lies before us. The splendid work which has been done by such men as Forney, Marshall and Basford has furnished a foundation and given this journal a standing which very few other publications in any field can have. With such an inspiration behind us it is little wonder that it has been possible to accomplish several things during the past year, or two, which have never before been attempted in technical journalism and which, it is believed, have effected far-reaching results.

This journal is the only one which devotes its entire energies to assisting the leading officers of the motive power, or mechanical, department in uplifting and bringing up the efficiency of that department. Besides keeping its readers fully informed as to the current progress in motive power department matters, including the design, maintenance and operation of locomotives, cars and other rolling stock, also of shops and roundhouses and the tools and appliances used in connection with them, special attention has been given to the larger problems, the proper solution of which will not only greatly increase the efficiency and effectiveness of the motive power department, but will eventually place it in the position in the general railroad organization which its importance deserves.

* * * * * * *

There is no more important problem now before the motive power officers than that of organization and during the past two years this matter has received our most careful attention, finally culminating in the article on "Organization," which appears in this issue. There has been a great dearth of published information on this subject and, as a matter of fact, but few officers, either on railroads, or in industrial establishments, have grasped the subject in its entirety. Many instances may be cited of officers who have fully appreciated some of the fundamental principles, but we believe that the Lake Shore organization presents the best example of what may be considered an ideal and well balanced organization.

* * * * * * *

An organization can never become strong unless it has some means for recruiting and raising the level of the men in the ranks. For many years railroad officials have realized that the prevailing apprentice systems were not at all adequate, but it remained for G. M. Basford to finally present a logical solution to the question. The ideas thus presented were promptly adopted by the New York Central Lines and as soon as these general principles were worked out in practice, and their success fully demonstrated, a complete study of all the details of the new system was presented in this journal, which occupies the unique position of being the only one in the railroad field which has systematically followed up the matter of rational apprenticeship, giving its readers the benefit of the best practice and most advanced thought on this subject.

* * * * * * *

An organization to be most effective must be one in which the individual efficiency of every man in it has been brought to the highest possible point. The bonus system, which is used on the Santa Fe, might better be called an individual efficiency system. This work, which was started in the locomotive repair shops at Topeka, has gradually spread until it promises eventually to include every man in the motive power department. The only thorough and complete account of this work, ever published, appeared in this journal in December, 1906, and was really the first one of the larger problems of which a complete study has been presented in one issue of the journal, rather than the older method of scattering a large and important article over several issues. Our readers have been kept in touch with the expansion of the betterment work on the Santa Fe by at least a dozen other articles which have appeared, from time to time, during the past two years, and which were either gathered from the observations of the editors, or were prepared by the pioneers in this work, including such men as Harrington Emerson, H. W. Jacobs, Clive Hastings, C. J. Morrison, Raffe Emerson, J. F. Whiteford and J. E. Epler. A complete list of these articles will be found in a footnote on page 208 of the June, 1908, issue. They include articles on the bonus system, locomotive repair shop organization and operation, shop tools and equipment, standardization and manufacture of tools, the car department and roundhouse work.

* * * * * * *

It is easy to build a new shop plant, but it is pretty hard, after it is placed in operation, to perfect the organization to get the most out of it. This matter, and that of shop production improvements, has received careful attention in these columns, and many important articles have appeared between the time the betterment work in the Topeka shops was considered in December, 1906, and the description of the Collinwood shop organization, in this issue.

* * * * * * *

The railroads use in their locomotives one-quarter of all of the coal which is mined in this country and the fuel item is the largest single item of expense in conducting transportation. The attention which has been given to effecting economies in fuel has not been at all in proportion to its importance; as a matter of fact, on many roads it has been given practically no attention at all. On other roads some one phase of the question, which has attracted the attention of the officers, has been fully gone into. Articles which have been published relating to this matter were of a very general nature or covered only one or two phases of the subject. It remained for the editors of this journal, at a very heavy expense, to make a complete study of the entire subject, bringing out the best practices, as regards different features, which could be found on the various roads in this country. This article, which appeared in the April issue of this year, has given an impetus to the study of fuel economy, the value of which can hardly be overestimated.

The rapidly increasing price of lumber, and the splendid service which has been given by steel freight cars, has caused the officers on many roads to consider the use of such equipment. The most serious objection to adopting it was the matter of its maintenance and repair and the fact that little was known as to the life of such cars. To meet the demand for such information, several weeks were given to a study of the question, resulting in the article on "Maintenance and Repair of Steel Cars on the Baltimore & Ohio," which appeared in the May, '07, issue of this journal. This is the only complete study of the question which has appeared, before or since that time, and has been followed up in this journal by a similar article describing the repair and maintenance of steel freight cars on the Pittsburgh & Lake Erie Railroad (January, 1908).

* * * * * * *

The electrification of the New York Central, the New York, New Haven & Hartford and the Pennsylvania Railroads, in and about New York City, has hastened the advent of the steel passenger car. This journal has given greater attention to steel passenger car designs than any other publication and has been exceedingly fortunate in arranging with Messrs. Barba and Singer of the Pennsylvania Railroad, at Altoona, for a complete study of steel passenger car design, which has been running in serial form during the past year and will continue during the coming year, becoming even more interesting as it goes into the detail of the superstructure. These articles will close with a practical example, based on the theoretical analysis, as elaborated in the series.

* * * * * * *

The drawing room has never been given the consideration which it should have, but during the past few years its importance has become more and more apparent and, as small roads have been formed into large systems, it has become necessary to entirely reorganize it. We were fortunate in securing G. I. Evans, chief draftsman of the Canadian Pacific, to prepare an article on the drawing room system in use on that road, which is one of the best on any road on this continent. This article, like all of those previously mentioned, was practically a pioneer in its field and is the only complete study of its kind which, as far as we have been able to find, has ever been published.

* * * * * * *

Special attention has been given to the matter of new designs of machine tools, which have been brought out from time to time, and which are adapted to railroad shop work. Larger power, better equipped shops, better organization, the individual motor drive, and high speed steel have all combined to revolutionize the design of railroad shop machine tools and we have aimed to keep our readers fully informed as to the developments and progress in this field.

* * * * * * *

The problem of the electrification of steam roads has been considered in such a way as to meet the demands of our readers. The matter of standardization of locomotives, cars and shop tools has been steadily agitated. No other publication has given so much attention to the design of locomotive and car details. As an instance, the matter of the Walschaert valve gear may be mentioned. This is the only publication which has shown the complete details of several of the more important applications of this gear.

* * * * * * *

As an example of some of the new departures which have recently been added, the railroad club column deserves mention. This has met with the hearty approval of our readers, and it is the desire to handle it in such a way as to increase the interest in the work of these clubs.

Beginning with this issue a page each month will be devoted to data of special interest to the drafting room.

* * * * * * *

Investigations, which have been made, indicate that a surprisingly large number of our readers have the journal bound, and that it is regarded by many as the standard reference book of the mechanical department. Because of this, special attention has been given to the annual index during the past two years, and we have tried to make the index for 1908 the most complete of any which have preceded it.

* * * * * * *

This résumé of the work of the past two years will, we trust, give our readers a good idea of the policy and the spirit which will govern the editors in the work of the coming year. We wish to thank you for the hearty support which you have given us in the past and to wish you one and all a Merry Christmas and a Happy and Prosperous New Year.

FUEL ECONOMY.

The International Railway Fuel Association, which has recently been organized, as mentioned elsewhere in this issue, should receive the cordial and hearty support of railroad mechanical department officials. One hundred million tons of coal, or 25 per cent. of the total output, is used in railroad locomotives. Fuel for locomotives is the largest single item of expense in the cost of conducting transportation and this one item probably offers a greater opportunity for saving than is possible in any other branch of railroading. While the railroads have to some extent realized the importance of this question, yet their efforts in bringing about economies have been spasmodic and, generally speaking, have been directed toward some particular phase of the problem rather than toward handling it, as a whole, in a systematic manner. We were surprised, when making the study which resulted in the article on "Locomotive Fuel Economy," which appeared in the April issue, to see how little was being done to bring about greater efficiency and economy. The only way to get the best results is to follow the coal from its purchase, and its production in the mines, until it is consumed in the locomotive. The officers on many roads seem to be blissfully unaware of the possibilities in this direction, and there is no more promising field for a good lively association. We extend our best wishes for its success.

ORGANIZATION.

Undoubtedly many motive power officers, after reading the article on "Organization," will declare that they too have a general staff. As a matter of fact the greater number of the roads in this country have officers who would rightfully form part of such a staff, but the staff members are not giving nearly the returns they should simply because they are not properly organized and do not work together.

* * * * * * *

Giving a railroad foreman, or officer, a vacation of at least two weeks, with pay, is a profitable investment for any railroad. It refreshes the man and brings him back to his work with renewed vigor, but far more important, it furnishes a splendid test to determine whether the organization under him is in good condition. As a fundamental principle, no officer or foreman should be eligible for promotion unless he has a man under him who can step up and take his place successfully; his absence from the work, on a vacation, will demonstrate whether he is living up to this requirement.

* * * * * * *

Very few roads are making the most of their mechanical engineers' department. To make this department a success the mechanical engineer must be an executive officer and must be given a sufficient appropriation and backing to enable his office to anticipate the wants of the other branches of the department rather than to follow far in the rear, as is true in most cases. Too much emphasis cannot be laid upon the advantages of the system which is in use upon the Lake Shore.

THE RAILROAD CLUBS

Canadian Railway Club (Montreal).—Next meeting Tuesday, January 5. Prof. Bancroft will give a lecture on British Columbia.

At the meeting held December 1, E. P. Gutelius presented a paper on "Steel Rails."

The paper on freight car brakes, presented at the November meeting by W. V. Turner and S. W. Dudley, is probably the most complete study of this subject ever published. Some idea of its extensiveness may be gained from the fact that it requires 105 pages with two inserts and fifty illustrations. The paper opens with a discussion of the importance of the problem and is followed with a study of the development of freight car air brakes and a comparison of past and present conditions. This is followed by a description of the brake and its various features. A large number of charts, or diagrams, showing the results of different tests, are presented to illustrate the fundamental principles involved; to illustrate the rise and fall of brake pipe and brake cylinder pressures in long and short trains, both with the old and the new equipment; and to show the results of these improvements in actual service.

Secretary, Jas. Powell, P. O. Box 7, St. Lambert, near Montreal, Can.

Central Railway Club (Buffalo).—Next regular meeting, Friday, January 8.

At the November meeting George Wagstaff, formerly supervisor of boilers of the New York Central Lines and now with the American Locomotive Equipment Company, read a short paper on "The Relation of the Brick Arch to the Efficiency of the Present Day Locomotive Boiler." He spoke briefly of the history of the brick arch and of the development of locomotive boiler design. There is a great need for increased boiler capacity without adding materially to the present weights and advantage should be taken of every practical means looking toward this end. A general statement was made as to the advantages of the brick arch and attention was called to the Pennsylvania Railroad locomotive tests at St. Louis in which two consolidation engines with somewhat similar boilers were tested, one with a brick arch and the other without. The front end arrangement of these two boilers differed, but it was found that in the boiler with the brick arch a much smaller amount of cinders and sparks were drawn through the tubes and the temperature of the fire box was about 200 degrees higher.

Secretary, Harry D. Vought, 95 Liberty street, New York City.

New England Railroad Club (Boston).—Next meeting Tuesday, December 8. William F. Garcelon will speak on "The Railroad Man in Politics." The meeting will be held at the Copley Square Hotel—dinner at 6:30, meeting called to order at 8 P. M.

Secretary, George H. Frazier, 10 Oliver street, Boston, Mass.

New York Railroad Club.—The next meeting, December 18, will be the annual "Christmas Smoker."

At the November meeting, the result of the letter ballot for the election of officers was announced. The nominees, mentioned in our last issue, were all elected.

W. J. Harahan, in his paper on the elements which make a successful railway official, mentioned the following essentials: Honesty in its best sense—a studious and persistent effort to render just and fair treatment to all alike, whether great or small; loyalty; the gift of creating harmony which results in cooperation and teamwork; industry, or earnest, painstaking, patient and persevering effort to accomplish everything well and to do it cheerfully; thoroughness which in the end results in the saving of time and energy; love of work; common sense; originality; experience; ability to organize and systematize.

He mentioned the necessity of keeping in touch with conditions on the road; also of seeing that all instructions are properly prepared, are understood by those interested and lived up to. The successful officer must keep informed as to the progress made in his field by reading current technical literature and taking active part in technical associations and clubs. The employment, treatment and discipline of men requires the most careful consideration and study. The fundamental principles of business which are applicable to any successful industrial concern apply equally well to a railroad. Costs should be carefully studied and analyzed and if possible daily reports as to the previous day's business, including labor and material expenses, should be available. Last, but not least, the public should be treated with courtesy and frankness.

Secretary, Harry D. Vought, 95 Liberty street, New York City.

Northern Railway Club (Duluth, Minn.).—Next meeting December 26. Wayne A. Clark, chief engineer of the D. & I. R. R. R., will present a paper on "Concrete and Steel Ore Docks."

Instead of having the two papers, mentioned in our last issue, for the November meeting, the annual meeting, including a banquet and dance, was held at Superior. The papers by Messrs White and Richards are now scheduled for the January meeting.

Railway Club of Pittsburgh.—Next meeting Friday evening, December 18.

At the annual meeting in October the following officers were elected: D. J. Redding, master mechanic, P. & L. E. R. R., president; F. R. McFeatters, superintendent, Union R. R. Co., first vice-president; Wm. Elmer, Jr., master mechanic, Pennsylvania R. R., second vice-president; C. W. Alleman, P. & L. E. R. R., secretary; J. D. McIlwain, Main Belting Co., treasurer.

At the November meeting N. K. Hoffman, superintendent of car service, P. & L. E. R. R., read a paper on "Transportation." It was largely of a historical nature, but with some detail as to the methods of shipping and billing freight over different rail roads, and a prophecy as to the future of water transportation and its effect upon rail transportation.

Secretary, C. W. Alleman, P. & L. E. R. R., Pittsburgh, Pa.

Richmond Railroad Club.—Next meeting Monday, December 14.

Alex Kearney's paper on "Locomotive Flues—Endurance of Materials," read at the October meeting, is a most interesting and valuable contribution on this subject. Although the different parts of locomotive boilers have been strengthened and redesigned to meet the more severe demands and service of recent years, practically no change has been made in the flue and its method of application, except that it has been lengthened. The effects of excessive rolling were illustrated by photographs. Attention was directed to the guttering of the flue sheet due to use of the beading tool. Experiments are now being made to see if the beading cannot be done away with by using the reinforced flue sheet, as shown on page 206 of the June issue of this journal.

The major portion of Mr. Kearney's paper was given over to a consideration of the proper material for flues. Some interesting experiments were cited to show that the beads at the firebox end of the flue absorb a certain amount of sulphur and this apparently shortens the life of the flue. Apparently the hot flues absorb a certain amount of the gases which pass through them and the exact effect of this upon the endurance of the material should be determined and be taken into consideration by manufacturers of flues.

Secretary, F. O. Robinson, 8th and Main streets, Richmond, Va.

St. Louis Railway Club.—Next meeting Friday, December 11. Samuel D. Webster, freight claim agent of the Terminal Railroad Association of St. Louis, will present a paper on "The Adjustment of Claims for Loss and Damage of Freight." This is also the "Annual Christmas Smoker"; the meeting will be held in the large dining room of the Southern Hotel.

At the October meeting W. G. Besler, vice-president and general manager of the Central Railroad of N. J., and the second president of the St. Louis Railroad Club, spoke briefly of the opportunities open to the poor boy; he commented at length upon the fact that legislation has come to be considered the grand panacea to be invoked to cure "all the ills that flesh is heir to" and stated that the threatening evil of the present time is abnormal regulation. He showed that there are cerain natural laws governing the railroads which are far more effective than any artificial ones which may be made.

At the November meeting John J. Baulch, president of the club, presented a paper entitled "Are Railroad Clubs Worth While?"

Secretary, B. W. Frauenthal, Union Station, St. Louis, Mo.

Western Railway Club (Chicago).—Next meeting Tuesday, December 15. J. J. Hennessey, master car builder of the Chicago, Milwaukee & St. Paul Ry., will read a paper on "The Abuse of the Repair Card."

At the November meeting Prof. Chas. H. Benjamin, dean of the School of Engineering and director of the engineering laboratory, Purdue University, Lafayette, Ind., presented a paper on "Flat Spots on Car Wheels." In analyzing the problem, the formula for the energy of impact of a flat wheel, developed by Prof. E. L. Hancock of Purdue University (see AMERICAN ENGINEER, May, 1908, page 188) was used. Prof. Benjamin also described a testing machine with which experiments could be made and from the results of these a working formula could be developed for practical use. In the discussion the proof sheets of a paper, which H. H. Vaughan had prepared for the December issue of the AMERICAN ENGINEER, were read (see page 475), in which it was shown that Prof. Hancock's formula is incorrect, not being based on the proper assumptions.

Geo. A. Post, president of the Railway Business Association, addressed the club on "Railroads and the Business Revival."

Secretary, J. W. Taylor, 390 Old Colony Building, Chicago, Ill.

EFFECT OF FLAT WHEELS ON RAILS.

H. H. VAUGHAN.

In the May number of THE AMERICAN ENGINEER, page 188, an article appeared by Mr. E. L. Hancock, discussing the effect of a flat wheel on a rail in which it was calculated that the blow delivered by the wheel was exceedingly serious in its amount and increased very considerably with the speed. This calculation was based on two assumptions, namely, that the weight carried by the wheel could be considered as a weight concentrated at the center of the axle, and that the leading edge of the flat spot remained in contact with the rail, while this weight described a circle around it. Neither of these assumptions is justifiable. In the first place, allowing that the wheels, together with such other parts of a car or tender as are carried below the springs, may be considered as concentrated at the axle, the body of the car is spring supported and cannot be considered as acting in the manner assumed, and in the second place the edge of a flat spot on a wheel with any given weight concentrated at its center would not remain in contact with the rail after a certain critical speed is reached.

A more reasonable method of considering this problem is to assume that the weight supported by each wheel below the springs is concentrated at the center of the axle and that this weight is pressed down by a force equal to the weight supported by each wheel above the springs and these quantities may be roughly taken at 1,600 lbs. and 14,400 lbs., respectively, giving a total weight per wheel of 16,000 lbs., or of 128,000 lbs. per car.

On this basis the problem has been thoroughly worked out by Mr. L. S. Spilsbury, of the office of the Engineer of Bridges, Canadian Pacific Railway, whose mathematical discussion is given below.

The results of this thorough and ingenious analysis are entirely different from those previously obtained and may be summarized as follows:

The striking velocity of the trailing edge of the flat spot on the rail increases proportionately to the speed up to a critical speed at which the leading edge leaves the rail. This critical speed under the assumption as to weights, etc., specified above, is about 21 feet per second, or 14.5 miles per hour for a 33-inch wheel.

After this critical speed is reached, there is a small range of higher speeds during which the leading edge of the flat spot after leaving the rail hits it again almost instantly, then one slightly higher speed at which the flat surface strikes the rail, after which the leading edge of the flat spot, after leaving the rail, does not again touch it, and the wheel leaves the rail until the trailing edge of the flat spot strikes it; this last condition continues indefinitely as the speed increases.

After this last condition is reached the velocity with which the trailing edge of the flat spot strikes the rail is constant. It varies, for small flats, directly as the length of the flat, directly as the square root of the ratio between the total weight supported by the wheel to the weight below the springs and inversely as the square root of the radius of the wheel. For a 33-inch wheel supporting a total weight equal to ten times the weight below the springs, this constant and maximum striking velocity is as follows:

For 3" flat spot.................. 3.8 feet per second.
For 4½" flat spot.................. 5.7 feet per second.
For 6" flat spot.................. 7.6 feet per second.

The blow delivered by the wheel at these velocities corresponds to that delivered by a weight of 1,600 pounds falling through the following distances:

For 3" flat spot........................ 0.22 feet.
For 4½" flat spot........................ 0.50 feet.
For 6" flat spot........................ 0.89 feet.

The results of these calculations are in close accordance with practical experience, and the curious fact that the blow delivered by a flat spot is constant after a certain speed is reached corresponds with the sound given at varying speeds.

The blow delivered on a rail by a flat spot while severe is not to be compared with that of a 2,000-pound weight falling through several feet, and is well within the capacity of any sound rail to withstand.

The regulations of the Master Car Builders' Association give ample protection against excessive blows and do not allow wheels to run in a condition that may prove injurious to the rail.

Mr. L. S. Spilsbury's calculations are as follows:

Let R = radius of wheel in feet.
l = length of flat spot in feet.
d = depth of flat spot in feet.
V = velocity of center of wheel parallel to rail in f. s.
w = angular velocity of wheel $= \frac{V}{R}$
P = pressure of spring on wheel when motion is steady, in lbs. (This is assumed constant throughout.)
W = weight of wheel in lbs.

Then $(2R - d)\,d = \frac{l^2}{4}$ (See Fig. 1.)

$$a = \frac{\pi}{2} - 2\Phi = \frac{\pi}{2} - 2\sin^{-1}\frac{l}{2R}$$

When the wheel is in position shown in Fig. 1 it is instantaneously turning about O, and the resultant upward acceleration $= \frac{V^2}{R}$ f. s. per sec.

It also has a downward acceleration due to the spring

$$= \frac{P + W}{W} g = f.$$

So the point O will rise off the rail as soon as $\frac{V^2}{R} > f$

i. e., when $V > \sqrt{f R}$.

So the limiting speed, $V_{Lt} = \sqrt{f R}$ f. s.

I. Before the limiting velocity is reached.

V_s = striking velocity of pt $P = \frac{V}{R} l$.

So for any given wheel and flat spot, V_s will increase

C C_1 C_2 is path of centre of wheel from when C O is vertical until C P is vertical

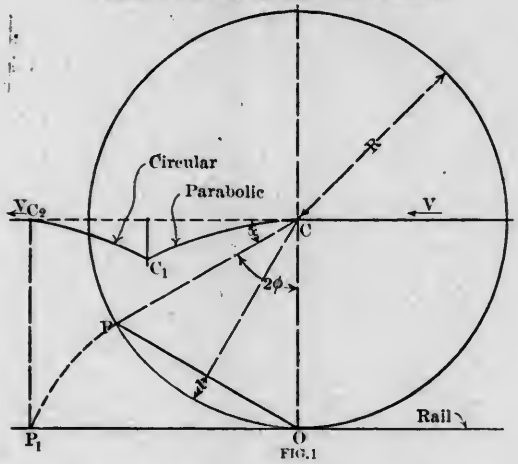


FIG. 1

uniformly until the limiting vel. is reached, when

$$V_s = V_{Lt} \times \frac{l}{R} = l\sqrt{\frac{f}{R}}$$

II. After the limiting velocity is reached.

Let t secs. = time taken from when O leaves the rail to when P strikes the rail.

Downward accel. of wheel $= f = \frac{P + W}{W} g$ f. s. per sec.

The motion of point P (see Fig. 2) is made up of two distinct motions:

(a) Translation. That of the wheel as a whole which moves Vt. ft. horz. forward and $\frac{1}{2}$ ft.² ft. vert. down.

(b) Rotation of wheel about its center through angle wt, during which P moves from P_0 down to the rail at P_1.

We have $P_0 P_1 = 2 R \sin \frac{wt}{2}$

$$\gamma = a + \frac{wt}{2}$$

$$P_0 N_1 = P_0 P_1 \cos \gamma = 2 R \sin \frac{wt}{2} \cos \left(a + \frac{wt}{2}\right)$$

$$P_1 N_1 = P_0 P_1 \sin \gamma = 2 R \sin \frac{wt}{2} \sin \left(a + \frac{wt}{2}\right)$$

Now $L_1 M + M P_0 + P_0 N_1 = CO = R$

$$\therefore \tfrac{1}{2} ft^2 + R \sin a + 2 R \sin \frac{wt}{2} \cos \left(a + \frac{wt}{2}\right) = R,$$

or $\frac{1}{2} ft^2 + R \sin (a + wt) = R$ ....(A)

Distance between points of departure and strike:

$= OP_1$

$= ON + NP_1$

$= Vt + R \cos (a + wt)$

At the instant of striking, vertical velocity of the wheel as a whole = ft downwards.

The velocity of P_1 due to rotation is V perpendicular to $C_1 P_1$. Its vertical component $= V \cos (a + wt)$.

$\therefore V_s = ft + V \cos (a + wt)$ ....(B)

From (B) we get:

$V_s = ft + Rw \cos (a + wt)$

$= ft + Rw \sin \left(\frac{\pi}{2} - a - wt\right)$

$= ft + Rw \left(\frac{\pi}{2} - a - wt\right)$, since $\left(\frac{\pi}{2} - a - wt\right)$ is very small

$= t (f - Rw^2) + Rw \left(\frac{\pi}{2} - a\right)$ ....(C)

From (A) we get:

$$\tfrac{1}{2} ft^2 + R \cos \left(\frac{\pi}{2} - a - wt\right) = R$$

or $\frac{1}{2} ft^2 + R \left[1 - \frac{\left(\frac{\pi}{2} - a - wt\right)^2}{2}\right] = R$, since $\left(\frac{\pi}{2} - a - wt\right)$ is small.

or $t \left(w + \sqrt{\frac{f}{R}}\right) = \frac{\pi}{2} - a$

Substituting in (C) for t, we get:

$$V_s = \left(\frac{\pi}{2} - a\right) \left[\frac{f - Rw^2}{w + \sqrt{\frac{f}{R}}} + Rw\right]$$

$$= \left(\frac{\pi}{2} - a\right) \left[\frac{f + Rw\sqrt{\frac{f}{R}}}{w + \sqrt{\frac{f}{R}}}\right]$$

$$= 2 \sin^{-1} \left(\frac{l}{2 R}\right) \times \sqrt{f R}$$

For small flats, $\sin^{-1} \frac{l}{2 R} = \frac{l}{2 R}$

$\therefore V_s = 2 \frac{l}{2 R} \times \sqrt{f R} = l\sqrt{\frac{f}{R}}$ ....(D)

After the limiting velocity is reached.

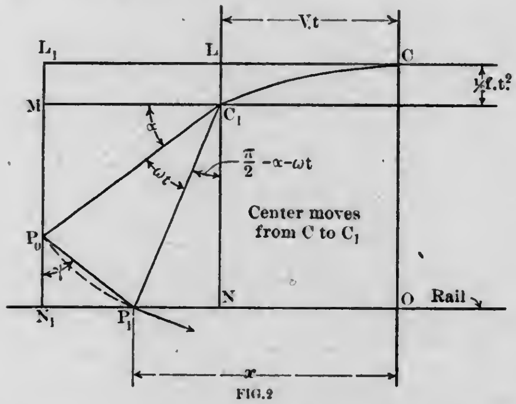


FIG. 2

THE ANGLE INDICATED BY THE GREEK LETTER ALPHA IN THIS DIAGRAM IS DESIGNATED BY THE LETTER a IN THE FORMULI.

This shows that after the limiting velocity is reached, the striking velocity becomes independent of the wheel's velocity, and is constant for any given wheel and flat spot:

For any given wheel, V_s varies directly with the length of flat spot.

The general result is therefore:

Before limiting velocity is reached

$V_s = \frac{V}{R} l$, increasing uniformly from 0 to $l\sqrt{\frac{f}{R}}$

After limiting velocity is reached

$$V_s = l\sqrt{\frac{f}{R}}$$

Concrete Road for Automobiles.—The Long Island Motor Parkway, which will eventually have a length of some 60 miles at about the axis of the length of Long Island, is a high speed automobile road with a reinforced concrete pavement. At present about nine miles have been finished. The Parkway is entirely on a private right of way, fenced in, and has no grade crossings. The concrete pavement is 22 ft. wide and over 6 in. thick and is reinforced with wire mesh placed near the bottom. The surface is left rough and sufficient lamp black is used in the mixture to give a pleasing light gray color. The roadway is intended entirely for automobiles and the curves are banked for a speed of 60 miles per hour. All curves and grades are very easy. A toll will be collected for the use of this road.

MALLET ARTICULATED COMPOUND LOCOMOTIVE FOR ROAD SERVICE—MEXICAN CENTRAL RAILWAY.

MALLET ARTICULATED COMPOUND LOCOMOTIVE

MEXICAN CENTRAL RAILWAY.

The Baldwin Locomotive Works has recently completed a very large articulated compound locomotive for regular freight service on the Tamasopo Division of the Mexican Central Railway. This division has frequent curves of from 15 to 22 degrees, maximum grades of 3 per cent. and is laid with 85-lb. rails.

The locomotive is of the 2-6-6-2 type and is very similar in every way to the five locomotives built by this company about two years ago for pushing service on the Great Northern Railway. These engines were illustrated on page 371 of the October, 1906, issue of this journal. The Mexican Central engines are somewhat lighter, weighing but 338,000 lbs. total and 300,000 lbs. on drivers (both estimated weights), as compared with 355,000 and 316,000 lbs. for the Great Northern engines. This difference in weight is probably largely accounted for in the difference in size of the two boilers, the Mexican Central engine having a straight top boiler, 70 in. in diameter, while the Great Northern engine was of the Belpaire type 84 in. in diameter at the front ring. There is a difference of over 20 per cent. in the amount of heating service in the two cases, made up practically altogether by the difference in the number of tubes, as the length is the same in both cases; the Great Northern engines having 441-2-¼ in. tubes, while the Mexican Central engine has but 350 tubes of the same size. Since oil is to be burned in the latter the grate is made narrower and longer but gives the same ratio to heating surface as is found in the larger boiler. In other respects the Mexican Central engines, although they are intended for regular road service, differ from the pushers only in the details which have been improved in view of the experience gained from the operation of the earlier design. McCarroll air reversing gear is used; the trailing truck is equipped with a special arrangement of side bearings and the reversing gear has the universal joint to prevent disturbance of the valve gear on the front engines when curving, all of which features were incorporated in the former design.

The tender is arranged for a capacity of 8,000 gallons of water and 3,500 gallons of fuel oil, the oil tanks being above the water tanks, both being wedge shaped.

The headlight will be seen to have been located in an unusual position and much nearer the rails than has before been considered necessary or desirable, even for slow speed freight locomotives.

The general dimensions, weights and ratios are as follows:

GENERAL DATA.	
Gauge	4 ft. 8½ in.
Service	Freight
Fuel	Oil
Tractive effort	71,600 lbs.
Weight in working order, estimated	338,000 lbs.
Weight on drivers, estimated	300,000 lbs.
Weight on leading truck, estimated	19,000 lbs.
Weight on trailing truck, estimated	19,000 lbs.
Weight of engine and tender in working order, est.	495,000 lbs.
Wheel base, driving	9 ft. 2 in.
Wheel base, total	44 ft. 2 in.
Wheel base, engine and tender	70 ft. 11 in.
RATIOS.	
Weight on drivers ÷ tractive effort	4.20
Total weight ÷ tractive effort	4.70
Tractive effort × diam. drivers ÷ heating surface	873.00
Total heating surface ÷ grate area	74.00
Firebox heating surface ÷ total heating surface, per cent	4.45
Weight on drivers ÷ total heating surface	66.50
Total weight ÷ total heating surface	74.50
Volume equiv. simple cylinders, cu. ft.	20.75
Total heating surface ÷ vol. cylinders	217.00
Grate area ÷ vol. cylinders	2.93
CYLINDERS.	
Kind	Mallet Comp.
Diameter and stroke	21½ & 33 x 32 in.
Kind of valves	Bal. Slide
WHEELS.	
Driving, diameter over tires	55 in.
Driving, thickness of tires	3½ in.
Driving journals, main, diameter and length	10½ x 12 in.
Driving journals, others, diameter and length	10 x 12 in.
Engine truck wheels, diameter	28½ in.
Engine truck, journals	6 x 12 in.
Trailing truck wheels, diameter	28½ in.
Trailing truck, journals	6 x 12 in.
BOILER.	
Style	Straight
Working pressure	200 lbs.
Outside diameter of first ring	78 in.
Firebox, length and width	123½ x 71 in.
Firebox plates, thickness	3/8 & 9/16 in.
Firebox, water space	5 in.
Tubes, number and outside diameter	350—2¼ in.
Tubes, length	21 ft.
Heating surface, tubes	4311 sq. ft.
Heating surface, firebox	201 sq. ft.
Heating surface, total	4512 sq. ft.
Grate area	61 sq. ft.
TENDER.	
Frame	12 in. chan.
Wheels, diameter	33 in.
Journals, diameter and length	5½ x 10 in.
Water capacity	8000 gals.
Oil capacity	3500 gals.

SUPPLY OF CRUDE RUBBER.—Many people are asking whether or not the supply of crude rubber will soon be exhausted. I might say that the supply is practically inexhaustible. In Brazil there are thousands of miles not yet opened up; the same thing applies to Africa and other sources. Then, again, Ceylon and the Straits Settlements are planting trees by the million. The reason rubber has advanced so rapidly in price is because of the increased demand.—*A. D. Thornton, general technical superintendent, Canadian Rubber Company, before the Canadian Railway Club.*

DEVELOP YOUR SUBORDINATES.—He should surround himself with the most capable men he can find for the respective positions under him. Some men, by their actions, seem to feel that brilliant subordinates may detract from them. There can be no more mistaken idea, nor can there be a more short-sighted policy. A man of moderate capacity, can, in a relatively high position, be successful with good and capable subordinates—but a brilliant man cannot be successful with incompetent subordinates because of the very physical impossibility of one individual knowing the details of a large business.—*W. J. Harahan, before the New York Railroad Club.*

It also has a downward acceleration due to the spring $\frac{P + W}{W} g = f$.

So the point O will rise off the rail as soon as $\frac{V^2}{R} > f$

i. e., when $V > \sqrt{fR}$.

So the limiting speed, $V_{lt} = \sqrt{fR}$ f. s.

I. Before the limiting velocity is reached.

V_s = striking velocity of pt $P = \frac{V}{R} l$.

So for any given wheel and flat spot, V_s will increase

C C_1 C_2 is path of centre of wheel from when C O is vertical until C P is vertical

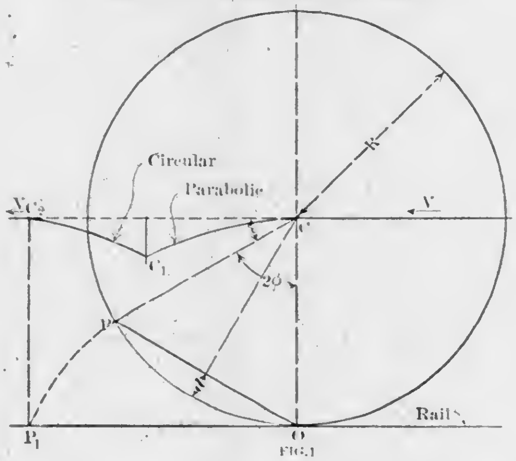


FIG. 1

uniformly until the limiting vel. is reached, when

$$V_s = V_{lt} \times \frac{l}{R} = l\sqrt{\frac{f}{R}}$$

II. After the limiting velocity is reached.

Let t secs. = time taken from when O leaves the rail to when P strikes the rail.

Downward accel. of wheel $= f = \frac{P + W}{W} g$ f. s. per sec.

The motion of point P (see Fig. 2) is made up of two distinct motions:

(a) Translation. That of the wheel as a whole which moves Vt. ft. horz. forward and ½ ft.^{2} ft. vert. down.

(b) Rotation of wheel about its center through angle wt, during which P moves from P_0 down to the rail at P_1.

We have $P_0 P_1 = 2 R \sin \frac{wt}{2}$

$$\gamma = a + \frac{wt}{2}$$

$$P_0 N_1 = P_0 P_1 \cos \gamma = 2 R \sin \frac{wt}{2} \cos \left(a + \frac{wt}{2}\right)$$

$$P_1 N_1 = P_0 P_1 \sin \gamma = 2 R \sin \frac{wt}{2} \sin \left(a + \frac{wt}{2}\right)$$

Now $L_1 M + M P_0 + P_0 N_1 = CO = R$

$$\therefore \tfrac{1}{2} ft^2 + R \sin a + 2 R \sin \frac{wt}{2} \cos \left(a + \frac{wt}{2}\right) = R,$$

or $\tfrac{1}{2} ft^2 + R \sin (a + wt) = R$ ....(A)

Distance between points of departure and strike:

$= OP_1$

$= ON + NP_1$

$= Vt + R \cos (a + wt)$

At the instant of striking, vertical velocity of the wheel as a whole = ft downwards.

The velocity of P_1 due to rotation is V perpendicular to $C_1 P_1$. Its vertical component $= V \cos (a + wt)$.

$\therefore V_s = ft + V \cos (a + wt)$ ....(B)

From (B) we get:

$$V_s = ft + Rw \cos (a + wt)$$

$$= ft + Rw \sin \left(\frac{\pi}{2} - a - wt\right)$$

$= ft + Rw \left(\frac{\pi}{2} - a - wt\right)$, since $\left(\frac{\pi}{2} - a - wt\right)$ is very small

$= t (f - Rw^2) + Rw \left(\frac{\pi}{2} - a\right)$ ....(C)

From (A) we get:

$$\tfrac{1}{2} ft^2 + R \cos \left(\frac{\pi}{2} - a - wt\right) = R$$

or $\tfrac{1}{2} ft^2 + R \left[1 - \frac{\left(\frac{\pi}{2} - a - wt\right)^2}{2}\right] = R$, since $\left(\frac{\pi}{2} - a - wt\right)$ is small.

$$\text{or } t \left(w + \sqrt{\frac{f}{R}}\right) = \frac{\pi}{2} - a$$

Substituting in (C) for t, we get:

$$V_s = \left(\frac{\pi}{2} - a\right) \left[\frac{f - Rw^2}{w + \sqrt{\frac{f}{R}}} + Rw\right]$$

$$= \left(\frac{\pi}{2} - a\right) \left[\frac{f + Rw\sqrt{\frac{f}{R}}}{w + \sqrt{\frac{f}{R}}}\right]$$

$$= 2 \sin^{-1} \left(\frac{l}{2R}\right) \times \sqrt{fR}$$

For small flats, $\sin^{-1} \frac{l}{2R} = \frac{l}{2R}$

$\therefore V_s = 2 \frac{l}{2R} \times \sqrt{fR} = l \sqrt{\frac{f}{R}}$ ....(D)

After the limiting velocity is reached,

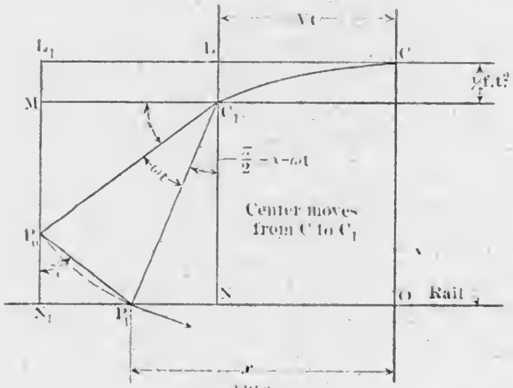


FIG. 2

THE ANGLE INDICATED BY THE GREEK LETTER ALPHA IN THIS DIAGRAM IS DESIGNATED BY THE LETTER *a* IN THE FORMULÆ.

This shows that after the limiting velocity is reached, the striking velocity becomes independent of the wheel's velocity, and is constant for any given wheel and flat spot:

For any given wheel, V_s varies directly with the length of flat spot.

The general result is therefore:

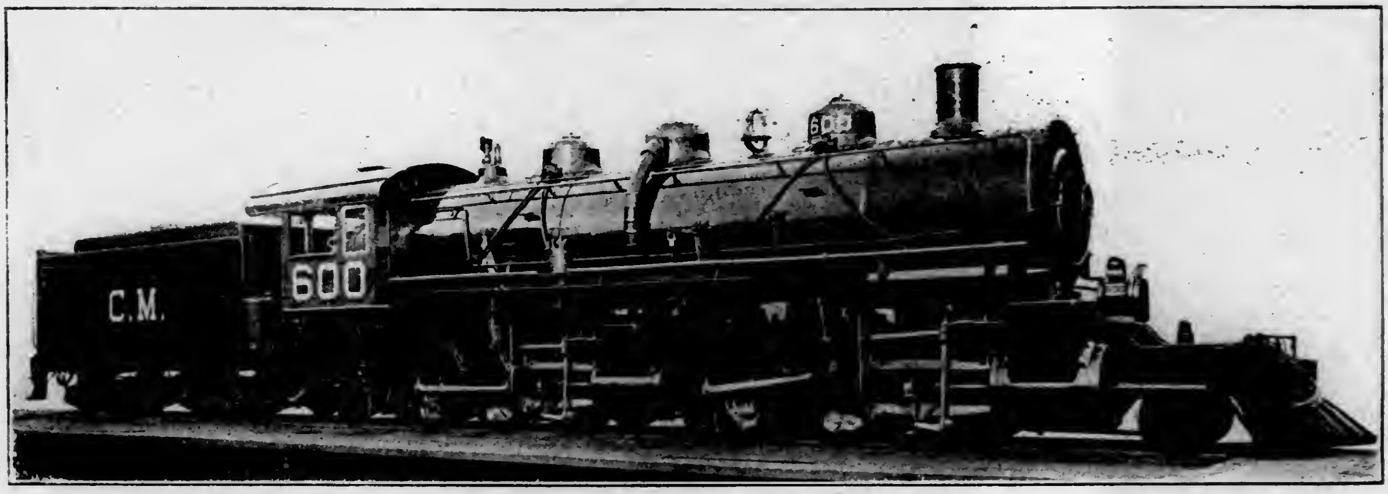
Before limiting velocity is reached

$V_s = \frac{V}{R} l$, increasing uniformly from o to $l\sqrt{\frac{f}{R}}$

After limiting velocity is reached

$$V_s = l\sqrt{\frac{f}{R}}$$

Concrete Road for Automobiles.—The Long Island Motor Parkway, which will eventually have a length of some 60 miles at about the axis of the length of Long Island, is a high speed automobile road with a reinforced concrete pavement. At present about nine miles have been finished. The Parkway is entirely on a private right of way, fenced in, and has no grade crossings. The concrete pavement is 22 ft. wide and over 6 in. thick and is reinforced with wire mesh placed near the bottom. The surface is left rough and sufficient lamp black is used in the mixture to give a pleasing light gray color. The roadway is intended entirely for automobiles and the curves are banked for a speed of 60 miles per hour. All curves and grades are very easy. A toll will be collected for the use of this road.



MALLET ARTICULATED COMPOUND LOCOMOTIVE FOR ROAD SERVICE—MEXICAN CENTRAL RAILWAY.

MALLET ARTICULATED COMPOUND LOCOMOTIVE

MEXICAN CENTRAL RAILWAY.

The Baldwin Locomotive Works has recently completed a very large articulated compound locomotive for regular freight service on the Tamasopo Division of the Mexican Central Railway. This division has frequent curves of from 15 to 22 degrees, maximum grades of 3 per cent. and is laid with 85-lb. rails.

The locomotive is of the 2-6-6-2 type and is very similar in every way to the five locomotives built by this company about two years ago for pushing service on the Great Northern Railway. These engines were illustrated on page 371 of the October, 1906, issue of this journal. The Mexican Central engines are somewhat lighter, weighing but 338,000 lbs. total and 300,000 lbs. on drivers (both estimated weights), as compared with 355,000 and 316,000 lbs. for the Great Northern engines. This difference in weight is probably largely accounted for in the difference in size of the two boilers, the Mexican Central engine having a straight top boiler, 70 in. in diameter, while the Great Northern engine was of the Belpaire type 84 in. in diameter at the front ring. There is a difference of over 20 per cent. in the amount of heating service in the two cases, made up practically altogether by the difference in the number of tubes, as the length is the same in both cases; the Great Northern engines having 441-2-¼ in. tubes, while the Mexican Central engine has but 350 tubes of the same size. Since oil is to be burned in the latter the grate is made narrower and longer but gives the same ratio to heating surface as is found in the larger boiler. In other respects the Mexican Central engines, although they are intended for regular road service, differ from the pushers only in the details which have been improved in view of the experience gained from the operation of the earlier design. McCarroll air reversing gear is used; the trailing truck is equipped with a special arrangement of side bearings and the reversing gear has the universal joint to prevent disturbance of the valve gear on the front engines when curving, all of which features were incorporated in the former design.

The tender is arranged for a capacity of 8,000 gallons of water and 3,500 gallons of fuel oil, the oil tanks being above the water tanks, both being wedge shaped.

The headlight will be seen to have been located in an unusual position and much nearer the rails than has before been considered necessary or desirable, even for slow speed freight locomotives.

The general dimensions, weights and ratios are as follows:

GENERAL DATA.	
Gauge	4 ft. 8½ in.
Service	Freight
Fuel	Oil
Tractive effort	71,600 lbs.
Weight in working order, estimated	338,000 lbs.
Weight on drivers, estimated	300,000 lbs.
Weight on leading truck, estimated	19,000 lbs.
Weight on trailing truck, estimated	19,000 lbs.
Weight of engine and tender in working order, est.	495,000 lbs.
Wheel base, driving	9 ft. 2 in.
Wheel base, total	44 ft. 2 in.
Wheel base, engine and tender	70 ft. 11 in.
RATIOS.	
Weight on drivers ÷ tractive effort	4.20
Total weight ÷ tractive effort	4.70
Tractive effort × diam. drivers ÷ heating surface	873.00
Total heating surface ÷ grate area	74.00
Firebox heating surface ÷ total heating surface, per cent.	4.45
Weight on drivers ÷ total heating surface	66.50
Total weight ÷ total heating surface	74.50
Volume equiv. simple cylinders, cu. ft.	20.75
Total heating surface ÷ vol. cylinders	217.00
Grate area ÷ vol. cylinders	2.93
CYLINDERS.	
Kind	Mallet Comp.
Diameter and stroke	21½ & 33 x 32 in.
Kind of valves	Bal. Slide
WHEELS.	
Driving, diameter over tires	55 in.
Driving, thickness of tires	3½ in.
Driving journals, main, diameter and length	10½ x 12 in.
Driving journals, others, diameter and length	10 x 12 in.
Engine truck wheels, diameter	28½ in.
Engine truck, journals	6 x 12 in.
Trailing truck wheels, diameter	28½ in.
Trailing truck, journals	6 x 12 in.
BOILER.	
Style	Straight
Working pressure	200 lbs.
Outside diameter of first ring	78 in.
Firebox, length and width	123½ x 71 in.
Firebox plates, thickness	3/8 & 9/16 in.
Firebox, water space	5 in.
Tubes, number and outside diameter	350—2¼ in.
Tubes, length	21 ft.
Heating surface, tubes	4311 sq. ft.
Heating surface, firebox	201 sq. ft.
Heating surface, total	4512 sq. ft.
Grate area	61 sq. ft.
TENDER.	
Frame	12 in. chan.
Wheels, diameter	33 in.
Journals, diameter and length	5½ x 10 in.
Water capacity	8000 gals.
Oil capacity	3500 gals.

SUPPLY OF CRUDE RUBBER.—Many people are asking whether or not the supply of crude rubber will soon be exhausted. I might say that the supply is practically inexhaustible. In Brazil there are thousands of miles not yet opened up; the same thing applies to Africa and other sources. Then, again, Ceylon and the Straits Settlements are planting trees by the million. The reason rubber has advanced so rapidly in price is because of the increased demand.—*A. D. Thornton, general technical superintendent, Canadian Rubber Company, before the Canadian Railway Club.*

DEVELOP YOUR SUBORDINATES.—He should surround himself with the most capable men he can find for the respective positions under him. Some men, by their actions, seem to feel that brilliant subordinates may detract from them. There can be no more mistaken idea, nor can there be a more short-sighted policy. A man of moderate capacity, can, in a relatively high position, be successful with good and capable subordinates—but a brilliant man cannot be successful with incompetent subordinates because of the very physical impossibility of one individual knowing the details of a large business.—*W. J. Harahan, before the New York Railroad Club.*

A LOCOMOTIVE SCALE.

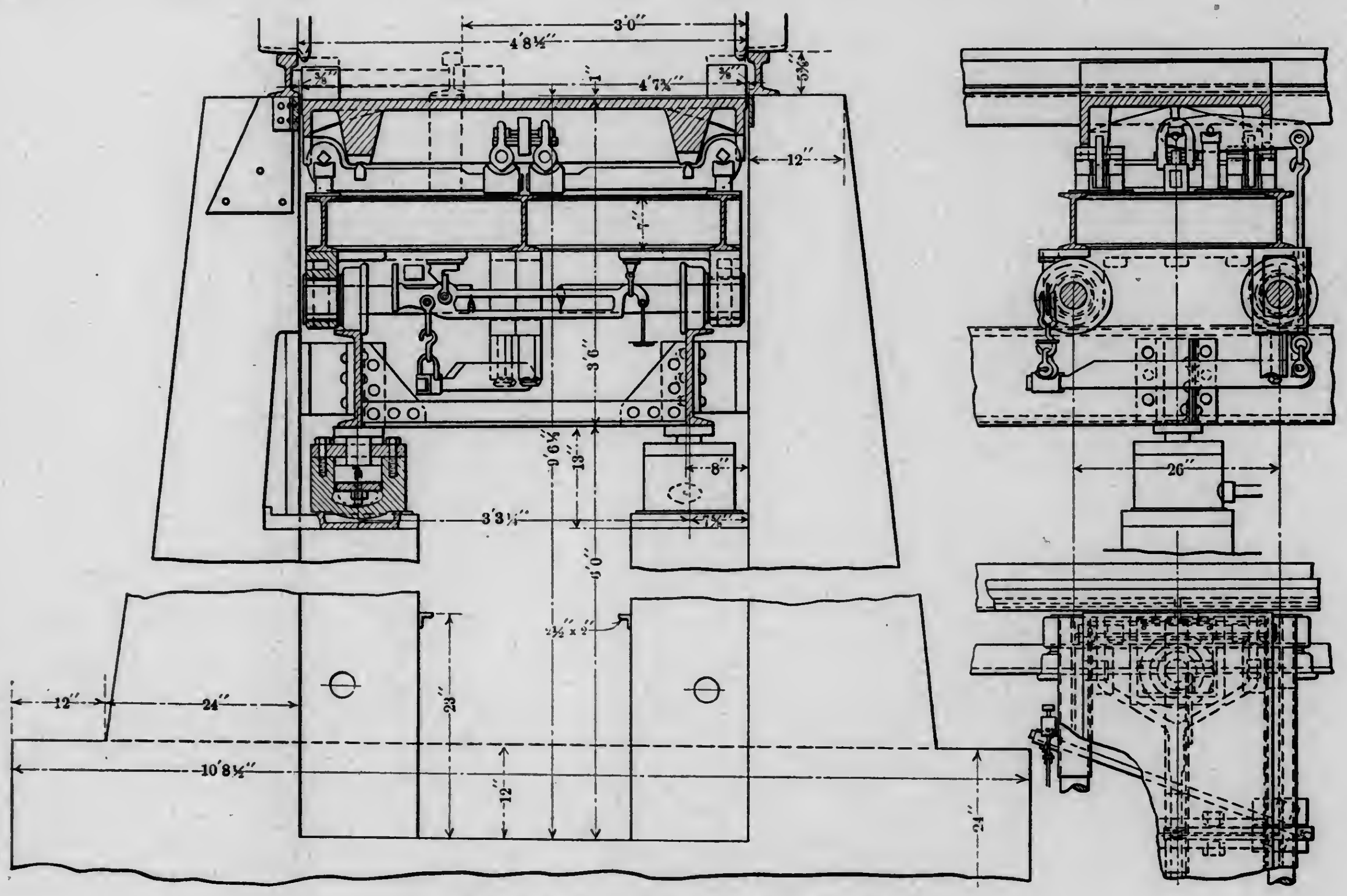
The American Locomotive Company has recently installed a locomotive scale, at its Schenectady works, with which the weight on each pair of wheels may be accurately obtained for any locomotive, from the smallest narrow gauge to the big Erie Mallet compound with eight pairs of drivers. If a locomotive should be built with a greater number of wheels, additional scale units may be added.

The old method of weighing the locomotive on an ordinary scale, obtaining the weight of different combinations of wheels and from these determining the weight on each pair, is not very satisfactory or accurate, even if the scale is in first-class condition. The scale at Schenectady is radically different from any which has thus far been built; it is placed on a substantial foundation, is installed in a special building to which only those in charge of the weighing have access, and is so designed that it is not subjected to any jars or shocks from locomotives or cars running over it.

There are several advantages in having such a scale. It affords a close check on the designers and estimators. Foreign roads are very particular about having the weights agree closely with the specifications and insist on having the actual weight on each pair of drivers checked accurately. Roads which wish to build engines of as large size and capacity as the roadbed will admit may be assured that the weight on any pair of drivers does not exceed the desired limit.

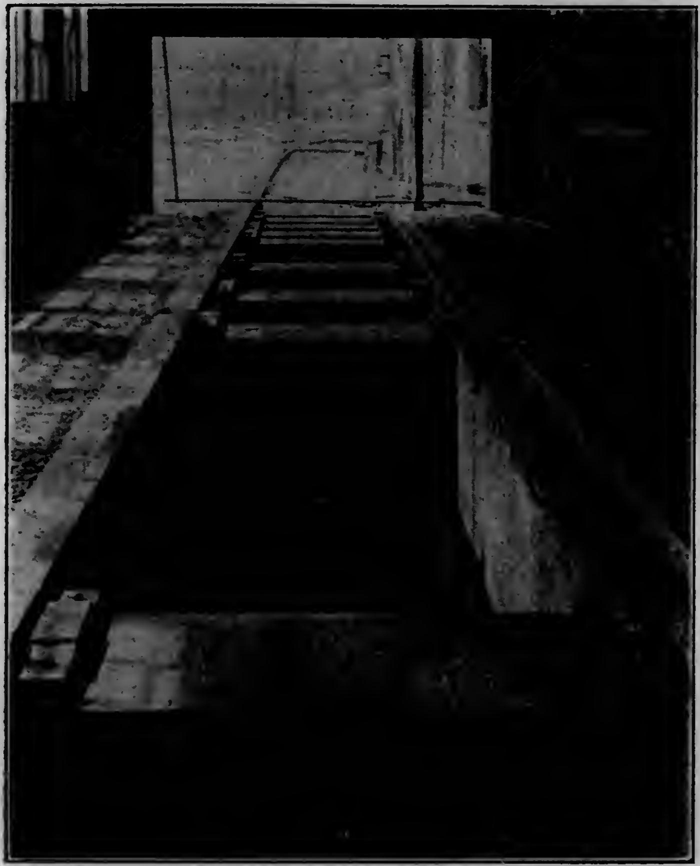
As may be seen from the illustrations, the scale consists of several (eight) 35-ton scales, each carried on a truck. The locomotive is run over the pit on the permanent track and a scale is placed centrally under each pair of wheels. Oil is forced into the small cylinders and the piston rods, on which the platform is supported, and the scale trucks are slowly and evenly raised upward, lifting the locomotive clear of the track. As the oil cylinders have been accurately leveled and the travel of each piston is exactly the same the distribution of the weight is not in any way disarranged.

Foundation.—The foundation is of concrete; it is 6 ft. 8½ in. wide and 53 ft. 4 in. long at the top, and 10 ft. 8½ in. wide and 55 ft. 4 in. long at the bottom. It is reinforced throughout with scrap rods. The scale platforms, when they rise, come in contact with the wheel flanges and for this reason the inner flanges of the rails have been planed off. To assist in supporting the rail and to keep the concrete from being broken away at the corners a plate 6 in. wide and ½ in. thick has been placed along the edge. At intervals of three feet, ½ in. anchor plates have been placed in the concrete; the side plate is attached to these by means of 3 x 3 x ½ in. angles. The rail is fastened to the foundation by anchor bolts spaced at proper intervals. The columns upon which the hydraulic cylinders rest are 14 x 15 in. in section, are an integral part of the foundation and reinforced and tied to it by ¼ x 2 in. straps set in the concrete. They are spaced 5 ft. apart.



LOCOMOTIVE SCALE—AMERICAN LOCOMOTIVE COMPANY.

Hydraulic Cylinders and Platform.—The cylinder castings set into heavy castings which not only form caps for the pillars, but are let into the side of the main foundation as shown. The cylinders have 6 in. pistons which, with 1,200 lbs. pressure per square inch, will lift 33,600 lbs. The total lift of the twenty-two cylinders is thus 739,200 lbs. The pistons are fitted with leather packing rings, as shown. The hydraulic pressure is furnished by an 1,800 lb. pressure pump driven by a belt from a shaft extending through from the wheel shop. The piping is 1 in. D. E. S. Where it is necessary for it to pass through the concrete walls, or pillars, 4 in. galvanized iron pipe has been laid in the concrete. It is the practice, after the pistons have been forced upward to the limit of their travel, to shut off the pump in order to eliminate any vibration due to its impulses. Under the high pressure used there is a slight leakage at the piston packing and unless the weighing operations are conducted very quickly the pump has to be cut in again in order to keep the locomotive clear



LOCOMOTIVE SCALE.

of the permanent track. A simple pressure intensifier will shortly be installed, thus overcoming this difficulty. The platform, which rests upon the cylinders, consists of two 12 in., 40 lb. channels tied together by 12 in. channels at the ends and by 3 x 3 x ½ in. angles, as shown. There are angle plates at each of the cross braces which act as guides, coming in contact with the castings imbedded in the sides of the foundation.

Scale Trucks and Scales.—The wheels of the scale trucks run on the top of the 12 in. channels. The truck journals are equipped with ¾ in. cold rolled steel rollers, a steel bushing being forced into the bearing casting. The wheels are 8 in. and the journals 3½ in. in diameter. The truck side frame members are of cast iron and carry the 7 in. I-beams which support the scale mechanism. The platform of the scale is of cast steel, carefully ribbed to support different gauge locomotives. Because of the limitations in the width and length of the scale it was necessary to make it of very compact design. The supports for the main pivots at the corners are of cast steel. The distance of the bearing pivot from the main pivot is only 4½ in. and the end pivot is only 22½ in. from the main pivot. The main lever is of cast iron. The line drawings show clearly how the weights are transmitted to the scale beams.

The men who adjust the scale trucks and take the weights descend into the pit and by standing on the 2 x 2½ in. angles, running lengthwise and attached to the pillars, can perform their duties without inconvenience.

Weighing Narrow Gauge Locomotives.—To weigh narrow gauge locomotives arrangements have been made to place a temporary rail over the pit, supported by struts as shown by the dotted lines on the cross sectional view. A cast iron block will be placed on the scale platform alongside the track, as shown.

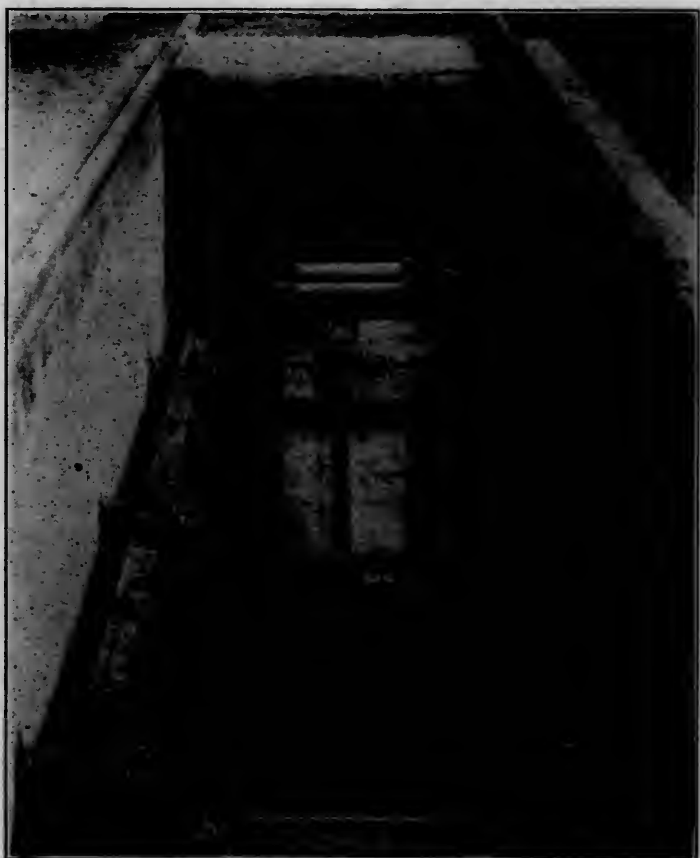
The general features of the scale were designed by the engineering department of the American Locomotive Company and the scales were designed and built by the Buffalo Scale Company.

The new Pennsylvania station in New York City will have 1,000,000 sq. ft. of solid masonry floors.

BEQUESTS TO THE M. C. B. & M. M. ASSOCIATIONS

There was probated on September 29 the will of Mrs. Luther G. Tillotson, containing bequests of $5,000 each to several associations, among them the American Railway Master Mechanics' Association and the Master Car Builders' Association. Mrs. Tillotson's bequest, undoubtedly made at the request of L. G. Tillotson, who died in 1885, recalls the memory of a fine type of railroad supply man. Tillotson's father was a pioneer builder of telegraph lines and the son became a telegraph operator in the service of the Erie Railroad. His name was known, and well-known, for many years and associated with that of General E. S. Greeley as dealers in railroad and electrical supplies on Dey street, New York.

THE BRICK ARCH.—In view of the recent great improvement in boiler care and maintenance, in addition to the successful treatment of water, and the successful improvements in hot water boiler washing plants, etc., the disadvantages claimed for the brick arch have almost been practically overcome. From the earliest history of the arch there does not seem to have been any question about its advantages and its value in locomotive operation, and therefore, with the wiping out of the disadvantages, the non-use of the brick arch means the practical throwing away of a large amount of valuable power. The arch is recognized as the most efficient device for reducing the quantity of sparks thrown from the stack, and, on this account, it becomes directly valuable as a fuel saver. It increases the length of the flame, and the finer fuel, when lifted from the grate, is baffled by the arch, and is consumed, instead of passing directly to the tubes and out of the stack in the form of sparks. It causes more equal distribution of the draft over the grate and thus improves the furnace action. Its function in the firebox being that of a mixer and baffle, brings about a more complete mingling of the gases, and thereby aids combustion, resulting in a higher temperature, and the production of a smaller proportion of carbonic oxide.—*George Wagstaff, before the Central Railway Club.*



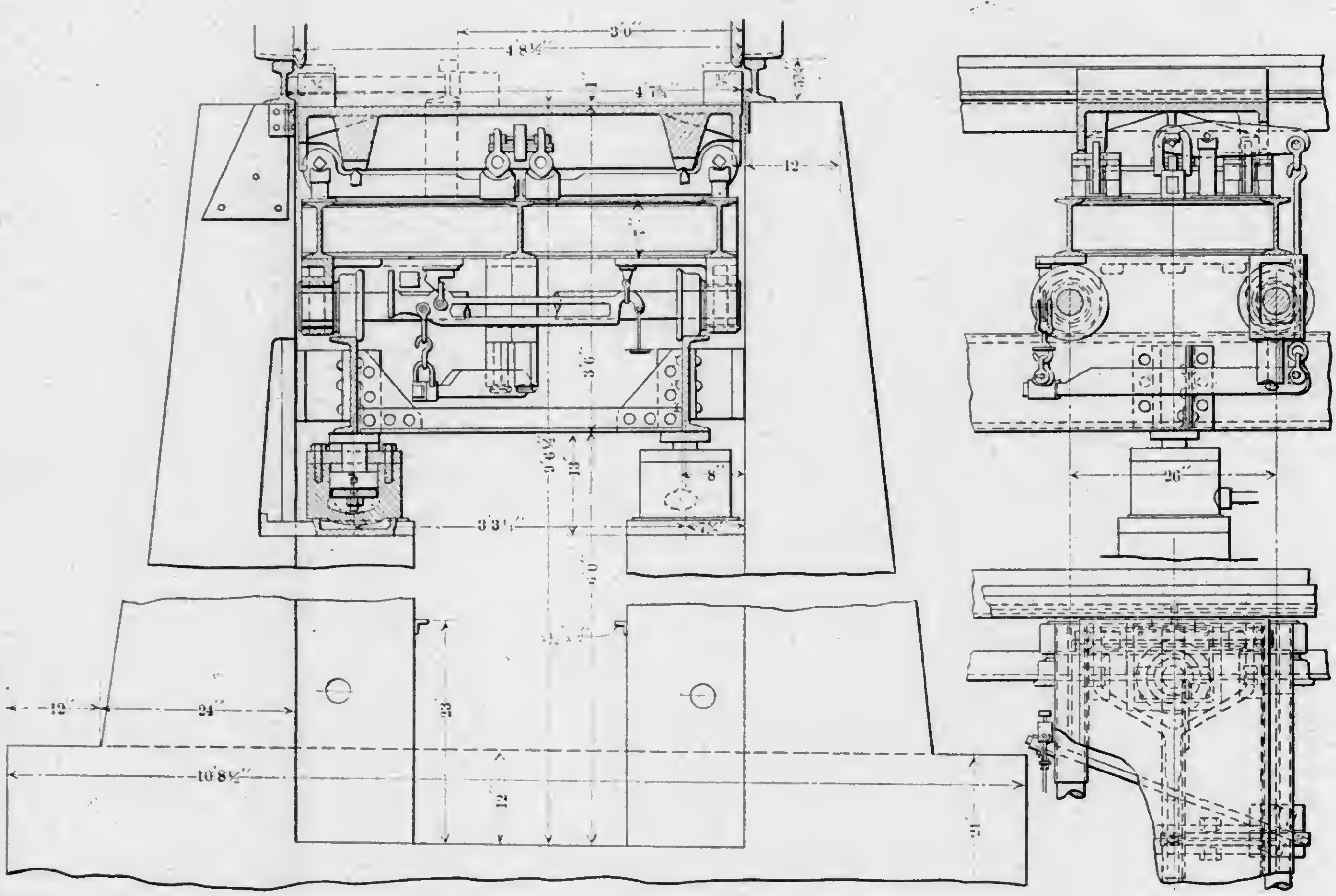
ONE OF THE SCALE TRUCKS.

A LOCOMOTIVE SCALE.

The American Locomotive Company has recently installed a locomotive scale, at its Schenectady works, with which the weight on each pair of wheels may be accurately obtained for any locomotive, from the smallest narrow gauge to the big Erie Mallet compound with eight pairs of drivers. If a locomotive should be built with a greater number of wheels, additional scale units may be added.

The old method of weighing the locomotive on an ordinary scale, obtaining the weight of different combinations of wheels and from these determining the weight on each pair, is not very satisfactory or accurate, even if the scale is in first-class condition. The scale at Schenectady is radically different from any which has thus far been built; it is placed on a substantial foundation, is installed in a special building to which only those piston is exactly the same the distribution of the weight is not in any way disarranged.

Foundation.—The foundation is of concrete; it is 6 ft. 8½ in. wide and 53 ft. 4 in. long at the top, and 10 ft. 8½ in. wide and 55 ft. 4 in. long at the bottom. It is reinforced throughout with scrap rods. The scale platforms, when they rise, come in contact with the wheel flanges and for this reason the inner flanges of the rails have been planed off. To assist in supporting the rail and to keep the concrete from being broken away at the corners a plate 6 in. wide and ½ in. thick has been placed along the edge. At intervals of three feet, ½ in. anchor plates have been placed in the concrete; the side plate is attached to these by means of 3 x 3 x ½ in. angles. The rail is fastened to the foundation by anchor bolts, spaced at proper intervals. The columns upon which the hydraulic cylinders rest are 14 x 15 in. in section, are an integral part of the foundation and reinforced



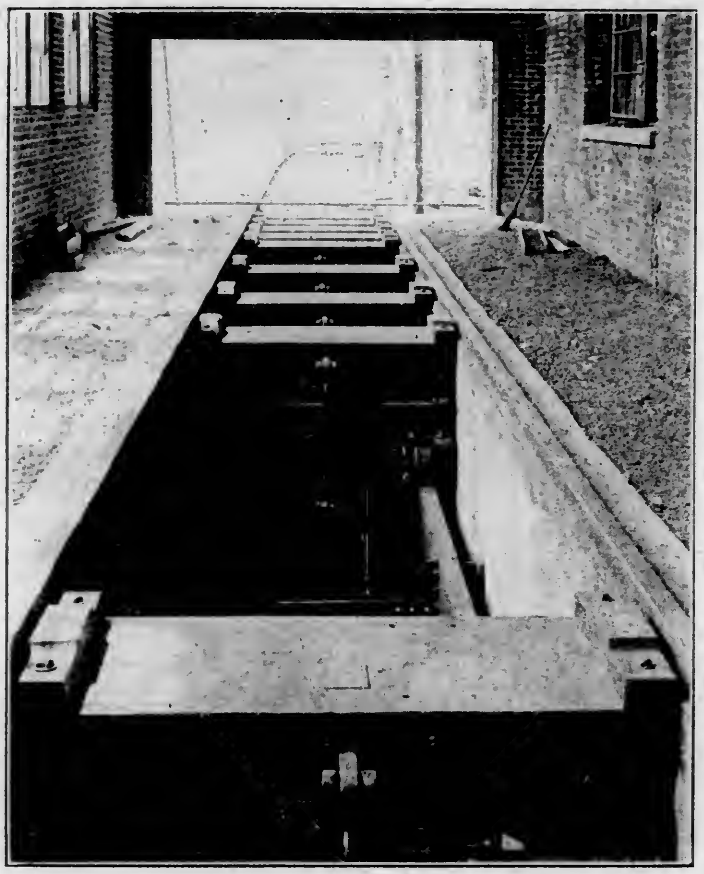
LOCOMOTIVE SCALE—AMERICAN LOCOMOTIVE COMPANY.

in charge of the weighing have access, and is so designed that it is not subjected to any jars or shocks from locomotives or cars running over it.

There are several advantages in having such a scale. It affords a close check on the designers and estimators. Foreign roads are very particular about having the weights agree closely with the specifications and insist on having the actual weight on each pair of drivers checked accurately. Roads which wish to build engines of as large size and capacity as the roadbed will admit may be assured that the weight on any pair of drivers does not exceed the desired limit.

As may be seen from the illustrations, the scale consists of several (eight) 35-ton scales, each carried on a truck. The locomotive is run over the pit on the permanent track and a scale is placed centrally under each pair of wheels. Oil is forced into the small cylinders and the piston rods, on which the platform is supported, and the scale trucks are slowly and evenly raised upward, lifting the locomotive clear of the track. As the oil cylinders have been accurately leveled and the travel of each and tied to it by ½ x 2 in. straps set in the concrete. They are spaced 5 ft. apart.

Hydraulic Cylinders and Platform.—The cylinder castings set into heavy castings which not only form caps for the pillars, but are let into the side of the main foundation as shown. The cylinders have 6 in. pistons which, with 1,200 lbs. pressure per square inch, will lift 33,600 lbs. The total lift of the twenty-two cylinders is thus 739,200 lbs. The pistons are fitted with leather packing rings, as shown. The hydraulic pressure is furnished by an 1,800 lb. pressure pump driven by a belt from a shaft extending through from the wheel shop. The piping is 1 in. D. E. S. Where it is necessary for it to pass through the concrete walls, or pillars, 4 in. galvanized iron pipe has been laid in the concrete. It is the practice, after the pistons have been forced upward to the limit of their travel, to shut off the pump in order to eliminate any vibration due to its impulses. Under the high pressure used there is a slight leakage at the piston packing and unless the weighing operations are conducted very quickly the pump has to be cut in again in order to keep the locomotive clear



LOCOMOTIVE SCALE.

of the permanent track. A simple pressure intensifier will shortly be installed, thus overcoming this difficulty. The platform, which rests upon the cylinders, consists of two 12 in., 40 lb. channels tied together by 12 in. channels at the ends and by 3 x 3 x ½ in. angles, as shown. There are angle plates at each of the cross braces which act as guides, coming in contact with the castings imbedded in the sides of the foundation.

Scale Trucks and Scales.—The wheels of the scale trucks run on the top of the 12 in. channels. The truck journals are equipped with ¾ in. cold rolled steel rollers, a steel bushing being forced into the bearing casting. The wheels are 8 in. and the journals 3½ in. in diameter. The truck side frame members are of cast iron and carry the 7 in. I-beams which support the scale mechanism. The platform of the scale is of cast steel, carefully ribbed to support different gauge locomotives. Because of the limitations in the width and length of the scale it was necessary to make it of very compact design. The supports for the main pivots at the corners are of cast steel. The distance of the bearing pivot from the main pivot is only 4½ in. and the end pivot is only 22½ in. from the main pivot. The main lever is of cast iron. The line drawings show clearly how the weights are transmitted to the scale beams.

The men who adjust the scale trucks and take the weights descend into the pit and by standing on the 2 x 2½ in. angles, running lengthwise and attached to the pillars, can perform their duties without inconvenience.

Weighing Narrow Gauge Locomotives.—To weigh narrow gauge locomotives arrangements have been made to place a temporary rail over the pit, supported by struts as shown by the dotted lines on the cross sectional view. A cast iron block will be placed on the scale platform alongside the track, as shown.

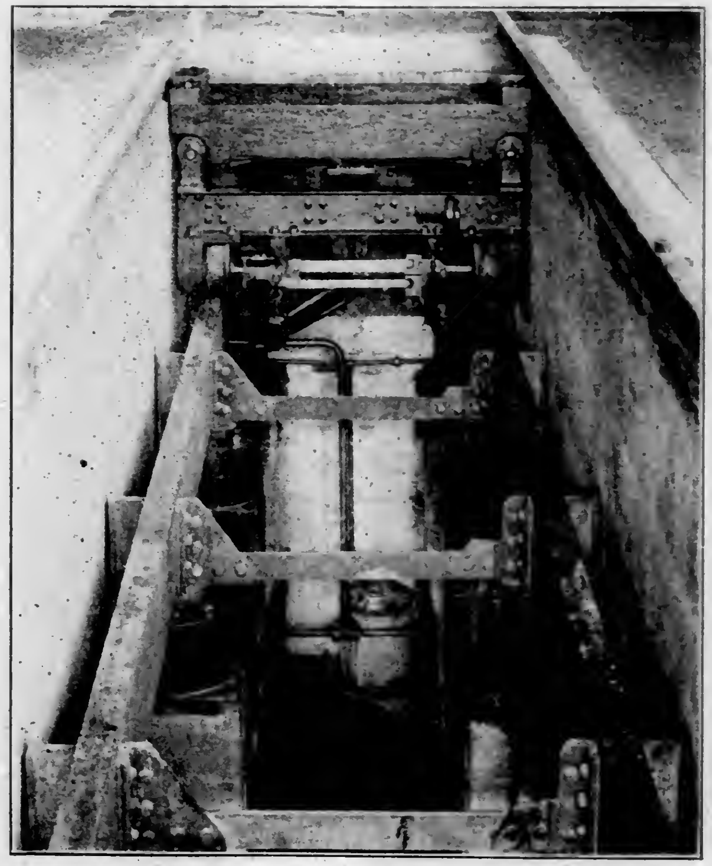
The general features of the scale were designed by the engineering department of the American Locomotive Company and the scales were designed and built by the Buffalo Scale Company.

The new Pennsylvania station in New York City will have 1,000,000 sq. ft. of solid masonry floors.

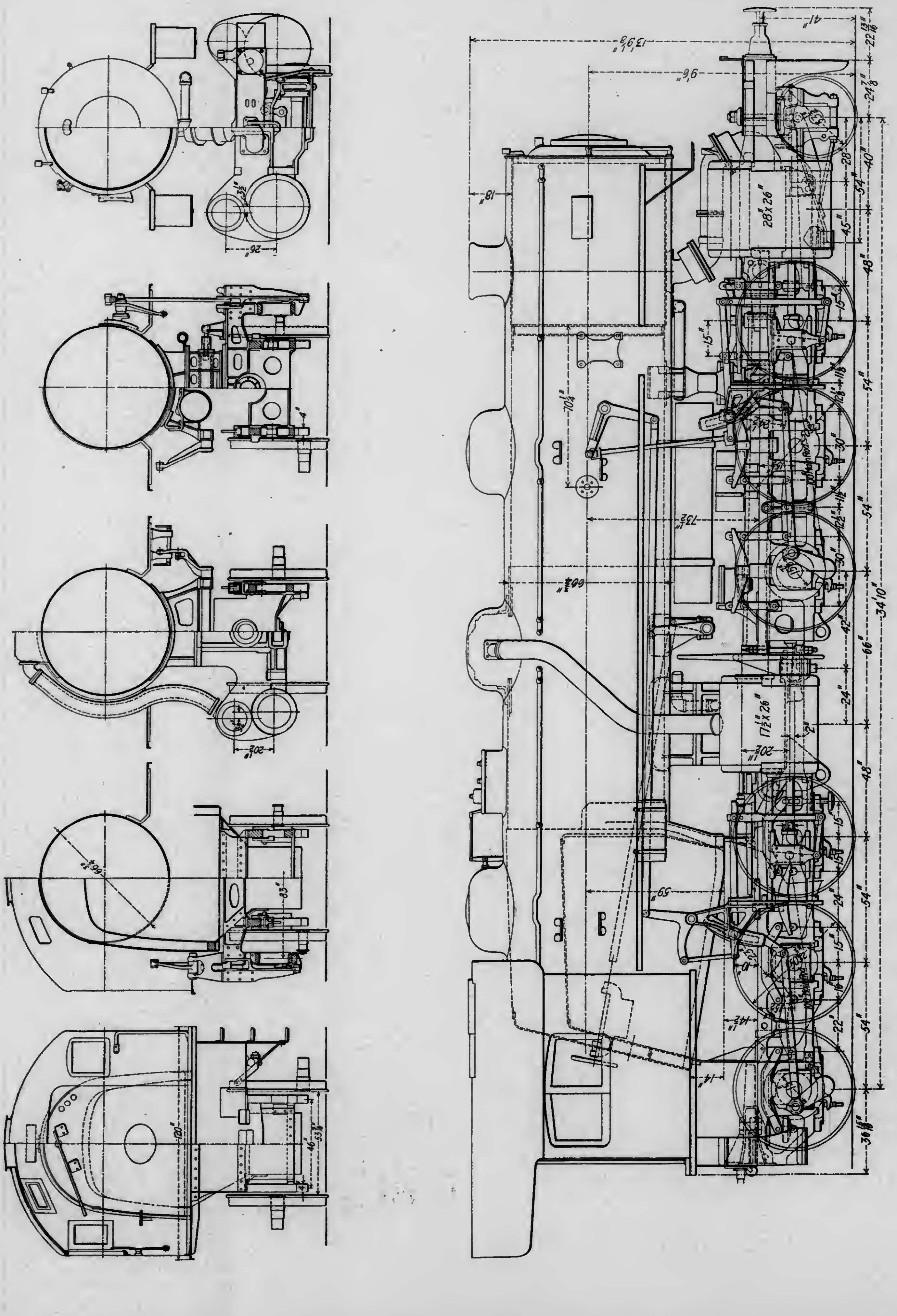
BEQUESTS TO THE M. C. B. & M. M. ASSOCIATIONS

There was probated on September 29 the will of Mrs. Luther G. Tillotson, containing bequests of $5,000 each to several associations, among them the American Railway Master Mechanics' Association and the Master Car Builders' Association. Mrs. Tillotson's bequest, undoubtedly made at the request of L. G. Tillotson, who died in 1885, recalls the memory of a fine type of railroad supply man. Tillotson's father was a pioneer builder of telegraph lines and the son became a telegraph operator in the service of the Erie Railroad. His name was known, and well-known, for many years and associated with that of General E. S. Greeley as dealers in railroad and electrical supplies on Dey street, New York.

THE BRICK ARCH.—In view of the recent great improvement in boiler care and maintenance, in addition to the successful treatment of water, and the successful improvements in hot water boiler washing plants, etc., the disadvantages claimed for the brick arch have almost been practically overcome. From the earliest history of the arch there does not seem to have been any question about its advantages and its value in locomotive operation, and therefore, with the wiping out of the disadvantages, the non-use of the brick arch means the practical throwing away of a large amount of valuable power. The arch is recognized as the most efficient device for reducing the quantity of sparks thrown from the stack, and, on this account, it becomes directly valuable as a fuel saver. It increases the length of the flame, and the finer fuel, when lifted from the grate, is baffled by the arch, and is consumed, instead of passing directly to the tubes and out of the stack in the form of sparks. It causes more equal distribution of the draft over the grate and thus improves the furnace action. Its function in the firebox being that of a mixer and baffle, brings about a more complete mingling of the gases, and thereby aids combustion, resulting in a higher temperature, and the production of a smaller proportion of carbonic oxide.—*George Wagstaff, before the Central Railway Club.*



ONE OF THE SCALE TRUCKS.



MALLET ARTICULATED COMPOUND FREIGHT LOCOMOTIVE FOR ROAD SERVICE—EASTERN RAILWAY OF FRANCE.

MALLET ARTICULATED COMPOUND LOCOMOTIVE

EASTERN RAILWAY OF FRANCE.

The American Locomotive Company has recently completed, at its Schenectady works, two Mallet compound locomotives of the 2-6-6-0 type for the Eastern Railway of France. These engines are intended for road service and will handle freight on a mining division of the road, where they replace four cylinder compound consolidation locomotives.

These locomotives are of special interest in several ways, one of which is the fact that with the exception of the threads on bolts and nuts, the tires, staybolts and boiler tubes, all parts of the engine are built to English measurement and the general design is decidedly American throughout.

The application of the front engine truck, which was specified by the railroad, compelled the designer to introduce features which have not heretofore been used on this type of locomotive in this country. With the exception of the front truck and the changes hinging on its use, this design is very similar in all respects to the engines built by the same company for the Central Railway of Brazil (see AMERICAN ENGINEER, December, 1907, page 485).

The application of truck wheels to locomotives of this type is a question that is receiving considerable discussion and is to be very fully treated by a paper before the American Society of Mechanical Engineers at the annual meeting of this year. In the present case their application compelled the location of the boiler considerably farther forward on the running gear than has been usual, in order to obtain a satisfactory distribution of weights. This places the high pressure cylinders but a short distance in front of the fire box and locates the low pressure cylinders in such a position as to make it necessary to extend the exhaust pipe to the forward side of the casting, in order to obtain sufficient length to prevent cramping on curves. Although the steam passages have been made liberal and the turns given as large a radius as possible, this presents a very tortuous passage for the exhaust steam, which, while objectionable, was unavoidable in this case.

It will be noted that there is but one boiler support on the front group of wheels, whereas previous designs have two or more, although but one is supposed to act under normal conditions. In the present case this arrangement was necessary in order to obtain the proper distribution of weights. It contains a spring centering device in the usual manner.

Another alteration has been made in this engine in connection with the intercepting valve, which has taken the ordinary form of the Richmond compound intercepting valve, in which the emergency exhaust valve is contained in the same chamber as the intercepting valve instead of being a separate mechanism on the outside of the cylinder casting.

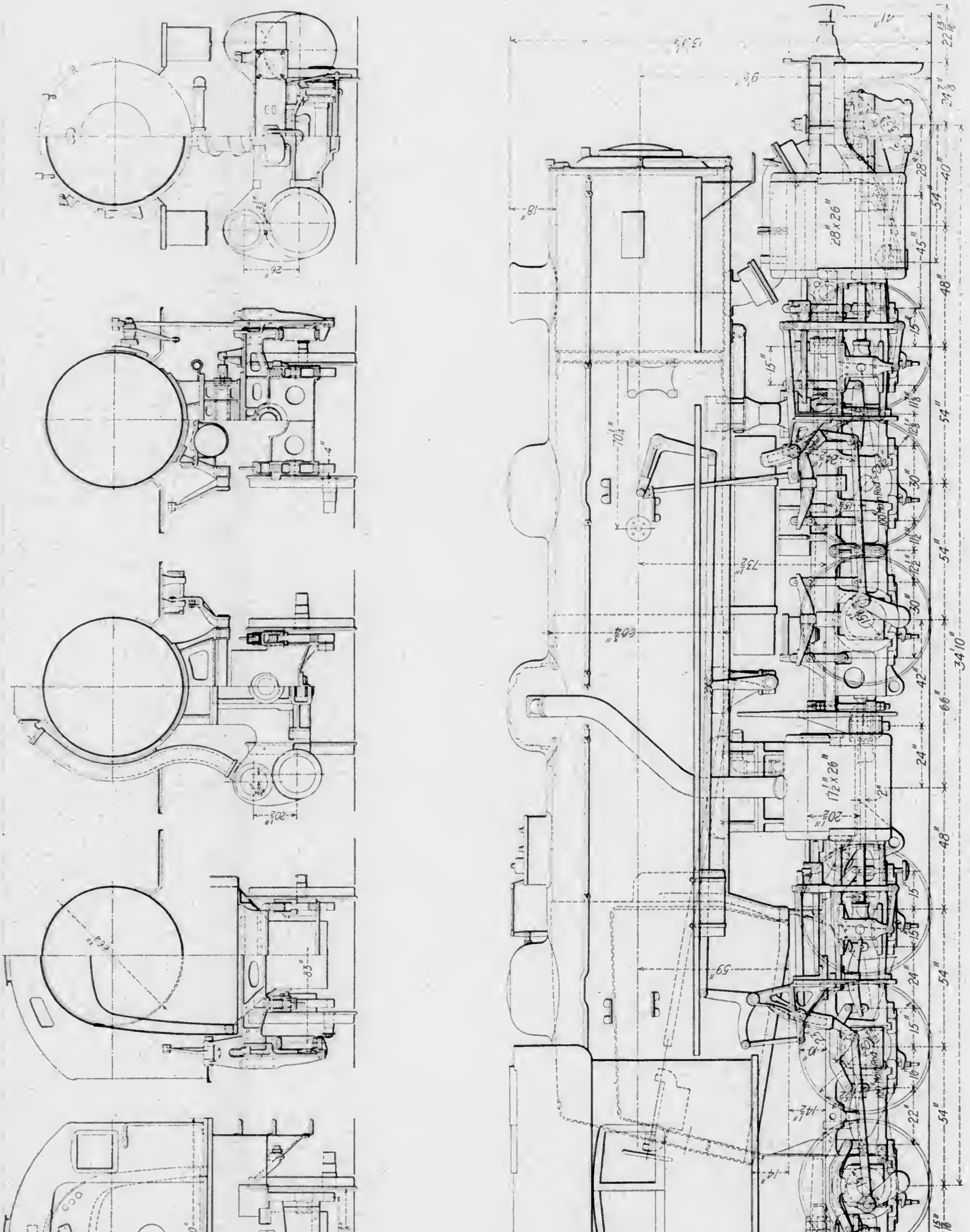
The boiler follows standard American practice, with the exception of the use of a copper inside fire box, copper stays and the metric tubes. Its dimensions, heating surface, etc., are given in the table below. The throttle is of the steam separator design, which was used on the Erie locomotives (AMERICAN ENGINEER, September, 1907, page 340).

As illustrating the advantages of the Mallet type locomotives for regular road service in connection with the reduction of weights of the moving and wearing parts the following comparison with a heavy consolidation on the New York Central Lines is interesting:

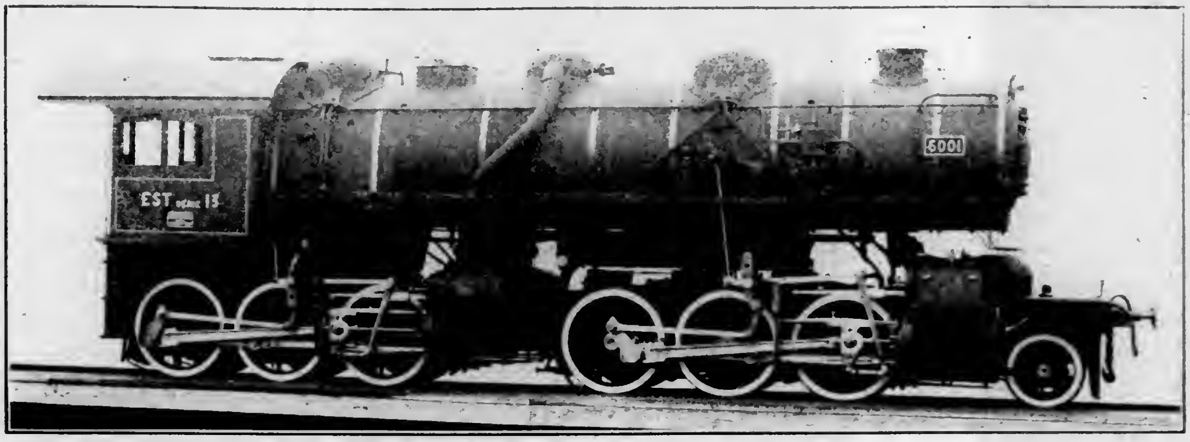
	Mallet.	Consolidated.
Total weight	206,000 lbs.	234,000 lbs.
Weight on drivers	182,000 lbs.	208,700 lbs.
Tractive effort	42,300 lbs.	45,700 lbs.
Diameter of driving wheels	50⅛ in.	63 in.
Weight of main rod	417 lbs.	850 lbs.
Weight of front rod	208 lbs.	181 lbs.
Weight of back rod	92 lbs.	310 lbs.
Weight of intermediate rod	———	391 lbs.
Weight of high pressure piston and rod	297 lbs.	664 lbs.
Weight of low pressure piston and rod	459 lbs.	———
Weight of cross heads	228 lbs.	375 lbs.
Weight of crank pin (one side)	184 lbs.	400 lbs.
Average wheel load	15,175 lbs.	26,088 lbs.

The general dimensions, weights and ratios of these locomotives are as follows:

GENERAL DATA.	
Gauge	4 ft. 8.9 in.
Service	Freight
Fuel	Bit. coal
Tractive effort	42,300 lbs.
Weight in working order	206,000 lbs.
Weight on drivers	182,000 lbs.
Weight on leading truck	24,000 lbs.
Wheel base, driving	9 ft.
Wheel base, total driving	34 ft. 10 in.
Wheel base, total engine	41 ft. 10 in.
RATIOS.	
Weight on drivers ÷ tractive effort	4.30
Total weight ÷ tractive effort	4.86
Tractive effort × diam. drivers ÷ heating surface	833.00
Total heating surface ÷ grate area	62.80
Firebox heating surface ÷ total heating surface, per cent	5.22
Weight on drivers ÷ total heating surface	71.50
Total weight ÷ total heating surface	80.80
Volume equiv. simple cylinders, cu. ft	10.60
Total heating surface ÷ vol. cylinders	240.00
Grate area ÷ vol. cylinders	3.82
CYLINDERS.	
Kind	Mellin comp.
Diameter and stroke	17½ and 28 x 26 in.
VALVES.	
Kind	Piston
Greatest travel	5" H. P.—5¼" L. P.
Outside lap	1" H. P.—⅞" L. P.
Inside clearance	⅛ in.
Lead in full gear	⅛ in.
WHEELS.	
Driving, diameter over tires	50⅛ in.
Driving, thickness of tires	3 1/16 in.
Driving journals, main, diameter and length	7½ x 9 in.
Driving journals, others, diameter and length	7 x 9 in.
Engine truck wheels, diameter	33½ in.
Engine truck journals	6 x 10 in.
BOILER.	
Style	Straight
Working pressure	214 lbs.
Outside diameter of first ring	66¾ in.
Firebox, length and width	89⅞, 64⅞ in.
Firebox plates, thickness	14 & 30 mm.
Firebox, water space	4 in.
Tubes, number and outside diameter	269—48¾ mm.
Tubes, length	18 ft.
Heating surface, tubes	2,414 sq. ft.
Heating surface, firebox	133 sq. ft.
Heating surface, total	2,547 sq. ft.
Grate area	40.5 sq. ft.
Smokestack, diameter	17 in.
Smokestack, height above rail	13 ft. 9½ in.



MALLET ARTICULATED COMPOUND FREIGHT LOCOMOTIVE FOR ROAD SERVICE.—EASTERN RAILWAY OF FRANCE.



MALLET ARTICULATED COMPOUND LOCOMOTIVE

EASTERN RAILWAY OF FRANCE.

The American Locomotive Company has recently completed, at its Schenectady works, two Mallet compound locomotives of the 2-6-6-0 type for the Eastern Railway of France. These engines are intended for road service and will handle freight on a mining division of the road, where they replace four cylinder compound consolidation locomotives.

These locomotives are of special interest in several ways, one of which is the fact that with the exception of the threads on bolts and nuts, the tires, staybolts and boiler tubes, all parts of the engine are built to English measurement and the general design is decidedly American throughout.

The application of the front engine truck, which was specified by the railroad, compelled the designer to introduce features which have not heretofore been used on this type of locomotive in this country. With the exception of the front truck and the changes hinging on its use, this design is very similar in all respects to the engines built by the same company for the Central Railway of Brazil (see AMERICAN ENGINEER, December, 1907, page 485).

The application of truck wheels to locomotives of this type is a question that is receiving considerable discussion and is to be very fully treated by a paper before the American Society of Mechanical Engineers at the annual meeting of this year. In the present case their application compelled the location of the boiler considerably farther forward on the running gear than has been usual, in order to obtain a satisfactory distribution of weights. This places the high pressure cylinders but a short distance in front of the fire box and locates the low pressure cylinders in such a position as to make it necessary to extend the exhaust pipe to the forward side of the casting, in order to obtain sufficient length to prevent cramping on curves. Although the steam passages have been made liberal and the turns given as large a radius as possible, this presents a very tortuous passage for the exhaust steam, which, while objectionable, was unavoidable in this case.

It will be noted that there is but one boiler support on the front group of wheels, whereas previous designs have two or more, although but one is supposed to act under normal conditions. In the present case this arrangement was necessary in order to obtain the proper distribution of weights. It contains a spring centering device in the usual manner.

Another alteration has been made in this engine in connection with the intercepting valve, which has taken the ordinary form of the Richmond compound intercepting valve, in which the emergency exhaust valve is contained in the same chamber as the intercepting valve instead of being a separate mechanism on the outside of the cylinder casting.

The boiler follows standard American practice, with the exception of the use of a copper inside fire box, copper stays and the metric tubes. Its dimensions, heating surface, etc., are given in the table below. The throttle is of the steam separator design, which was used on the Erie locomotives (AMERICAN ENGINEER, September, 1907, page 340).

As illustrating the advantages of the Mallet type locomotives for regular road service in connection with the reduction of weights of the moving and wearing parts the following comparison with a heavy consolidation on the New York Central Lines is interesting:

	Mallet.	Consolidated
Total weight	206,000 lbs.	231,000 lbs.
Weight on drivers	182,000 lbs.	208,700 lbs.
Tractive effort	42,300 lbs.	45,700 lbs.
Diameter of driving wheels	50⅛ in.	63 in.
Weight of main rod	417 lbs.	850 lbs.
Weight of front rod	208 lbs.	181 lbs.
Weight of back rod	92 lbs.	310 lbs.
Weight of intermediate rod	——	391 lbs.
Weight of high pressure piston and rod	297 lbs.	664 lbs.
Weight of low pressure piston and rod	459 lbs.	——
Weight of cross heads	228 lbs.	375 lbs.
Weight of crank pin (one side)	184 lbs.	400 lbs.
Average wheel load	15,175 lbs.	26,088 lbs.

The general dimensions, weights and ratios of these locomotives are as follows:

GENERAL DATA.

Gauge	4 ft. 8.9 in.
Service	Freight
Fuel	Bit. coal
Tractive effort	42,300 lbs.
Weight in working order	206,000 lbs.
Weight on drivers	182,000 lbs.
Weight on leading truck	24,000 lbs.
Wheel base, driving	9 ft.
Wheel base, total driving	34 ft. 10 in.
Wheel base, total engine	41 ft. 10 in.

RATIOS.

Weight on drivers ÷ tractive effort	4.30
Total weight ÷ tractive effort	4.86
Tractive effort × diam. drivers ÷ heating surface	833.00
Total heating surface ÷ grate area	62.80
Firebox heating surface ÷ total heating surface, per cent	5.22
Weight on drivers ÷ total heating surface	71.50
Total weight ÷ total heating surface	80.50
Volume equiv. simple cylinders, cu. ft	10.60
Total heating surface ÷ vol. cylinders	210.00
Grate area ÷ vol. cylinders	3.82

CYLINDERS.

Kind	Mellin comp.
Diameter and stroke	17½ and 28 x 26 in.

VALVES.

Kind	Piston
Greatest travel	5" H. P.—5¼" L. P.
Outside lap	1" H. P.—⅞" L. P.
Inside clearance	⅛ in.
Lead in full gear	⅛ in.

WHEELS.

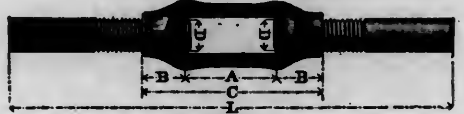
Driving, diameter over tires	50⅛ in.
Driving, thickness of tires	3 1/16 in.
Driving journals, main, diameter and length	7½ x 9 in.
Driving journals, others, diameter and length	7 x 9 in.
Engine truck wheels, diameter	33½ in
Engine truck journals	6 x 10 in.

BOILER.

Style	Straight
Working pressure	214 lbs.
Outside diameter of first ring	66¾ in.
Firebox, length and width	89⅞, 64⅞ in.
Firebox plates, thickness	14 & 30 mm.
Firebox, water space	4 in.
Tubes, number and outside diameter	269—48¾ mm.
Tubes, length	18 ft.
Heating surface, tubes	2,414 sq. ft.
Heating surface, firebox	133 sq. ft.
Heating surface, total	2,547 sq. ft.
Grate area	40.5 sq. ft.
Smokestack, diameter	17 in.
Smokestack, height above rail	13 ft. 9½ in.

TURNBUCKLES.

Dimensions.



D. Size = Outside Diameter of Screw.
A. Length in Clear between heads = 6 in. first length for all sizes.
B. Length of Tapped Heads = 1½ D. nearly.
C. Total length of Buckle without Bolt Ends = 6 in. + 3 D, nearly.
L. Total Length of Buckle and Stub ends when extended.

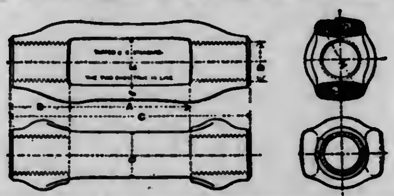
SIZE D.		L.		SIZE D.		L.	
3/8	Inch	22	Inch	2	Inch	29	Inch
7/16	"	22	"	2 1/8	"	29	"
1/2	"	22	"	2 1/4	"	30	"
9/16	"	22	"	2 3/8	"	31	"
5/8	"	22	"	2 1/2	"	32	"
3/4	"	23	"	2 5/8	"	32	"
7/8	"	24	"	2 3/4	"	33	"
1	"	25	"	2 7/8	"	33	"
1 1/8	"	25	"	3	"	34	"
1 1/4	"	26	"	3 1/8	"	36	"
1 3/8	"	27	"	3 1/4	"	36	"
1 1/2	"	27	"	3 3/8	"	37	"
1 5/8	"	28	"	3 1/2	"	37	"
1 3/4	"	28	"	3 3/4	"	39	"
1 7/8	"	29	"	4	"	41	"

L—A = Length of two stub ends.
The "Size" of the buckle is the outside diameter of the screw, same as bolts, nuts, etc.

Standard	Length,	6	Inches	between	Heads,	(A)	for all Sizes.
Second	"	9	"	"	"	(A)	"
Third	"	12	"	"	"	(A)	"
Fourth	"	15	"	"	"	(A)	"
Fifth	"	18	"	"	"	(A)	"
Sixth	"	24	"	"	"	(A)	"
Seventh	"	36	"	"	"	(A)	"
Eighth	"	48	"	"	"	(A)	"
Ninth	"	72	"	"	"	(A)	"

Dimensions in Detail

Pressed Wrought Iron Open Turnbuckles.



Size D Inches	A Inches	B Inches	C Inches	E Inches	F Inches	G Inches	H Inches
3/8	6	9/16	7 1/8	9/16	3/16	1/2	1 1/16
7/16	6	21/32	7 3/16	5/8	1/4	5/8	1 1/8
1/2	6	3/4	7 1/4	3/4	1/4	5/8	1 1/4
9/16	6	27/32	7 13/16	13/16	5/16	3/4	1 5/16
5/8	6	15/16	7 7/8	15/16	11/32	3/4	1 9/16
3/4	6	1 1/8	8 1/4	1 1/16	3/8	7/8	2
7/8	6	1 5/16	8 5/8	1 1/4	3/8	1	2 1/4
1	6	1 1/2	9	1 5/16	7/16	1 1/8	2 7/16
1 1/8	6	1 11/16	9 3/8	1 7/16	1/2	1 1/4	2 9/16
1 1/4	6	1 7/8	9 3/4	1 9/16	1/2	1 3/8	2 3/4
1 3/8	6	2 1/16	10 1/8	1 11/16	9/16	1 1/2	3 1/16
1 1/2	6	2 1/4	10 1/2	1 3/4	5/8	1 5/8	3 3/16
1 5/8	6	2 7/16	10 7/8	2	5/8	1 7/8	3 3/8
1 3/4	6	2 5/8	11 1/4	2 1/8	3/4	2	3 5/8
1 7/8	6	2 13/16	11 5/8	2 5/16	[illegible]	2 1/8	3 7/8
2	6	3	12	2 3/8	[illegible]	2 1/4	4
2 1/8	6	3 3/16	12 3/8	2 1/2	[illegible]	2 3/8	4 1/4
2 1/4	6	3 3/8	12 3/4	2 11/16	[illegible]	2 1/2	4 1/2
2 3/8	6	3 9/16	13 1/8	2 3/4	[illegible]	2 3/4	4 3/4
2 1/2	6	3 3/4	13 1/2	3 1/16	[illegible]	3	5 1/8
2 5/8	6	3 15/16	13 7/8	3 1/4	[illegible]	3	5 5/16
2 3/4	6	4 1/8	14 1/4	3 3/8	[illegible]	3 1/4	5 3/4
2 7/8	6	4 5/16	14 5/8	3 7/16	1 1/32	3 1/2	6 1/16
3	6	4 1/2	15	3 5/8	1 1/32	3 3/4	6 1/4
3 1/4	6	4 7/8	15 3/4				
3 1/2	6	5 1/4	16 1/2				
3 3/4	6	5 5/8	17 1/4				
4	6	6	18				
4 1/4	9	6 3/8	21 3/4				
4 1/2	9	6 3/4	22 1/2				
4 3/4	9	7 1/8	23 1/4				
5	9	7 1/2	24				

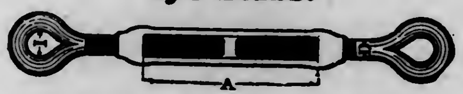
Dimensions E F G H depend upon the specifications of the Bars with which the Turnbuckles are to be used and will be supplied when these are known.
In ordering state size and ultimate tensile strength of Bars.

Weights of Turnbuckles in Pounds.

W. S.—With Stubs. N. S.—Without Stubs.

SIZE	6 Inches bet. heads.		9 Inches bet. heads.		12 Inches bet. heads.	
	W. S.	N. S.	W. S.	N. S.	W. S.	N. S.
3/8	.95	.49	....	....	....	....
7/16	1.35	.75	....	....	....	....
1/2	1.57	.75	1.94	1.	2.3	1.35
9/16	2.2	1.19	....	....	....	....
5/8	2.5	1.19	3.15	1.6	3.5	2.1
3/4	3.57	1.62	4.5	2.15	5.	2.66
7/8	4.8	2.05	5.7	2.6	7.75	3.9
1	6.7	2.85	7.6	4.4	10.	4.6
1 1/8	8.35	3.45	9.8	4.66	11.5	6.
1 1/4	10.75	5.15	12.5	6.	14.	7.35
1 3/8	13.	6.	15.25	7.25	17.6	9.5
1 1/2	15.95	7.75	18.9	9.55	21.6	11.5
1 5/8	19.3	8.85	22.5	11.	26.	13.5
1 3/4	21.6	9.95	25.6	12.5	30.5	15.5
1 7/8	26.8	12.5	30.	14.	35.	17.
2	30.8	13.95	35.2	16.	39.	19.
2 1/8	36.7	15.5	42.5	19.	44.5	22.5
2 1/4	43.	18.1	49.6	22.25	53.5	26.
2 3/8	50.	21.4	54.	25.5	66.	29.
2 1/2	58.	25.5	63.5	30.	72.	33.5
2 5/8	64.	27.5	72.5	34.	80.	36.
2 3/4	74.7	32.	80.5	37.75	85.	42.
2 7/8	78.	34.5	88.	41.	99.	47.
3	91.5	41.5	100.	45.5	110.	52.

Turnbuckles with Loop—Welded Eye Stubs.



Suitable sizes for different diameters of wire rope.

Diameter of Rope		D	I
Iron	Steel		
5/16		1/2	3/4
3/8		5/8	1
7/16		5/8	1 1/8
1/2	3/8	3/4	1 1/4
5/8	1/2	7/8	1 3/8
3/4	5/8	1	1 1/2
7/8	3/4	1 1/8	1 5/8
1	7/8	1 1/4	1 3/4
1 1/8	1	1 3/8	2
1 1/4	1 1/8	1 1/2	2
1 3/8	1 1/4	1 5/8	2 1/4
1 1/2	1 3/8	1 3/4	2 1/2
1 5/8	1 1/2	2	3
1 3/4	1 5/8	2 1/4	3 1/4
1 7/8	1 3/4	2 1/2	3 1/2
2	2	2 3/4	3 3/4
2 1/4	2 1/8	3	4
2 1/2	2 1/4	3 1/4	4 1/2

From pages 10, 11, 12 and 13 of the Handbook of the Cleveland City Forge & Iron Company, Cleveland, Ohio.

ELECTRIFICATION OF THE ST. CLAIR TUNNEL.

GRAND TRUNK RAILWAY.

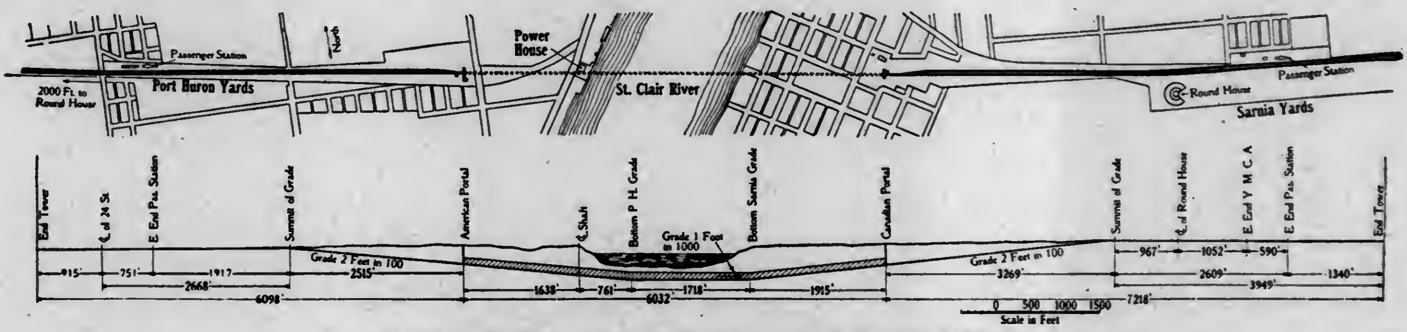
The formal opening of the electric train operation through the St. Clair tunnel took place on November 12, when the St. Clair Tunnel Co., a subsidiary of the Grand Trunk Railway, accepted the electric plant and equipment from the contractors, the Westinghouse Electric & Manufacturing Co. The event was celebrated by a large party of engineers and newspaper men who were invited to inspect the work.

The St. Clair Tunnel, which was opened for traffic in 1890, is located under the St. Clair River, and forms a connecting link between the terminal of the western division of the Grand Trunk Railway at Port Huron, Mich., and the terminal of the eastern division at Sarnia, Ontario. The length of the tunnel from portal to portal is 6,032 feet, the approaches being slightly over 2,500 feet, and nearly 3,300 feet in length, making the total distance between the American and the Canadian summits 12,000 feet, or about 2¼ miles. The grade on the tunnel approaches and the inclined sections of the tunnel is 2 per cent., while the flat middle section, about 1,700 feet in length, has a grade of 0.1 per cent. downward toward the east, just enough to provide for the proper drainage of any seepage water.

A single track extends through the tunnel, while a double track is laid in both of the approaches. The necessary tracks for trains handled to about 760 tons, and even with this load the speed up the 2 per cent. grade was often very slow. With the constantly increasing traffic, at times the capacity of the tunnel with its steam equipment was taxed in handling the tonnage delivered to the Tunnel Company, and it was thought desirable to make such changes in the operation of the tunnel as would increase its possible capacity for handling traffic, and at the same time obviate the danger and inconvenience due to the presence of the locomotive gases in the tunnel.

The advantage of the use of electric locomotives, on account of the freedom from smoke and the attendant discomfort, together with the possible greater economy in operation, led finally to the decision to provide an electrical equipment to handle the tunnel service, this equipment to provide for the operation of the trains through the tunnel by means of electric locomotives; the handling of the drainage and seepage water by means of electric pumps; the lighting of the passenger stations, the tunnel and the roundhouses by electricity, as well as furnishing a certain amount of power to the roundhouses; also, provision was made for a limited amount of outside lighting in the form of arc lamps. The different electrical systems available for such service were considered, and estimates as to the relative cost and efficiency of the various systems were prepared and submitted. Decision was finally made in favor of alternating current, using a 3-phase system for the distribution of power required for pumping and for shop motors with single phase distribution for locomotives and lighting.

In order to increase the capacity of the tunnel, it was desir-



PLAN AND PROFILE, ST. CLAIR TUNNEL—GRAND TRUNK RAILWAY.

handling the freight and passenger traffic are provided in the yards at Port Huron and Sarnia. The map and profile of the zone operated by the St. Clair Tunnel Company is shown above.

The disposal of the rainfall on the tunnel approaches requires particular attention. The areas of the Port Huron and Sarnia approaches are approximately 11 and 13 acres respectively. Water precipitated on these areas during a rainfall is discharged into waste ditches on the bank above by means of pumps of large capacity. Retaining levees have been constructed, so arranged as to impound a large proportion of the water falling on the approaches. By this method the pumps have to handle only the water falling on the central portion of the approach during the rainstorm. Later the impounded water is discharged into the pump sump by valves provided for the purpose.

As is evident, this pumping service is of great importance in the operation of the tunnel, as, should the tunnel become flooded with water, entire interruption of the traffic would ensue. For the operation of the steam drainage pumps, boiler plants were provided at each portal, and attendants are constantly on duty, it being necessary to keep up steam during a large part of the year in order to take care at a moment's notice of any rainfall that might occur.

Four steam locomotives of special design have been in commission since the construction of the tunnel. They were designed to provide the necessary high tractive effort required to operate the trains over the grades in the tunnel and on the approaches, and arranged to burn anthracite coal, in order to minimize the inconvenience due to excessive smoke in the tunnel. These locomotives have given good account of themselves, and have handled the traffic in a satisfactory way throughout their service. Their maximum tractive effort limited the weight of the able to provide for the maximum practicable tractive effort in the new locomotives. The capacity limit was determined by the maximum pull to which it was deemed wise to subject the drawbars on the mixed rolling stock that must be handled, without danger of breaking trains in two. With this in view the locomotives were specified to be of sufficient capacity to develop a drawbar pull of 50,000 pounds, when operating at a speed of 10 miles per hour. It was estimated that such a locomotive would be able to make the complete trip through the tunnel from terminal to terminal with a 1,000-ton train in fifteen minutes, or four 1,000-ton trains per hour, which would provide a capacity for traffic about three times larger than the actual maximum demands up to the present time.

It was estimated that the pumping service, for which adequate provision must be made, would require the installation at the Sarnia portal of two pumps each of capacity of 5,500 gallons per minute, and at the Port Huron portal the installation of two pumps each with a capacity of 4,000 gallons per minute. To provide absolute continuity of service, duplicate pumping equipments were provided in each portal, as well as duplicate feeder lines leading from the power plant to the pump houses.

The lighting service to be provided for is of minor importance in so far as the amount of power required at both Sarnia and Port Huron is concerned, this being somewhat less than 100 kw. The power requirement for motors in the roundhouses at Port Huron and Sarnia is about 100 kw. for both shops.

To furnish electrical energy for this service, provision must be made in the power plant for supplying single phase current for the electrical locomotives, 3-phase current for the pumping service, and 3-phase and single phase current both for the power and lighting service at various points throughout Port Huron and

Sarnia, as well as for a small amount of arc lighting.

Power Station.—The power station is situated on the Port Huron bank of the river, at a point almost directly over the tunnel. The building construction is of concrete to the dynamo room floor. The walls above this point are continued with paving brick and are corniced and coped with concrete. The roof is of cinder concrete. The dynamo room is lofty and well lighted. The walls are lined with enamel brick to the height of the switchboard, the remaining portion being lined with sand lime brick. The basement has plenty of head room and contains the condenser pump groups and stoker fan groups. The dynamo room floor is so recessed that the auxiliary apparatus in the basement is in view from the dynamo room floor. The boiler room floor is on the same level as the dynamo room basement floor. A striking feature of the boiler room is the reinforced concrete coal bunker. This extends the entire length of the boiler room, and has a capacity of 500 tons.

The power station equipment is in duplicate. There are two 1,250 kw., three-phase, 25-cycle, 3,300 volt turbo-generators, either of which is capable of handling the maximum demand upon the station. Each turbine has its independent barometric condenser. There are two steam driven exciters and a motor driven exciter group. The momentary peak loads have reached 2,400 kw., single-phase, and a Tirrill regulator has been provided to keep the voltage of the locomotive phase uniform over the entire range of load. There is in addition to the locomotive load a small three-phase load consisting of power house motors, drainage pump motors and roundhouse motors. The incandescent lighting is connected to same phase as the locomotives.

Since there is but a single track in the tunnel, there can be only one train on the grade at a time, consequently the load is an extremely variable one. The plant has been designed to meet this condition. The turbines have a large overload capacity and the boilers have extra large steam drum capacity. The four boilers have a nominal rating of 400 h.p. each, and each boiler has three steam drums. Ordinarily there are three boilers in use, although two are sufficient to care for the average load. Steam is kept up in the third boiler in order to avoid the delay which would occur in getting it into commission in case of an accident to an active boiler. When there is a drop in boiler pressure due to a heavy overload the speed of the forced draft fan engine is automatically increased, and at the same time the fuel supply to the underfeed stokers is automatically increased by the speeding up of the stoker feeding mechanism. The nominal boiler pressure is 200 pounds and the nominal turbine pressure is 175 pounds, consequently some drop in steam pressure is allowable, but the automatic action of the stokers is such as to keep the drop from becoming excessive. The separately fired superheater is of a type that has considerable heat storage capacity. The temperature is controlled by the means of dampers, which are automatically operated by a water piston whose valves are operated by an electro-magnet primarily controlled by a thermo-couple in the steam line. The automatic control is arranged for a low uniform superheat in order that there may be no wide variation of temperature in the exhaust portion of the turbine when a heavy change in load occurs. High pressure superheated steam is used in the turbine alone. An auxiliary steam line, tapped off between the boilers and the superheater and equipped with reducing valves, delivers low pressure saturated steam to the auxiliaries. The auxiliaries exhaust into a feed water heater. The boiler feed pumps draw their water supply from the condenser discharge.

The station was put in commission November, 1907, at which time it was thoroughly tested out with an artificial load that corresponded to actual service conditions. Later it was subjected to an official test and was found to more than meet the contract guarantees. The station has been operated from the start by the Tunnel Company's employees, although during the preliminary operating period the operation was nominally in the hands of the contractors. The station, while it is a simple one, contains refinements that good engineering demands. The load factor is necessarily bad, which fact, of course, is not conducive to economy. But the station has been designed to meet the tunnel conditions, and its economy is all that can be expected with a single track heavy grade freight load.

Distributing System.—Just outside the power station there is a vertical shaft which extends to the tunnel. A reinforced concrete duct chimney has been built in this shaft as a continuation of the power station duct lines. All the feeders pass from this chimney through holes in the tunnel shell into the tunnel. The locomotive feeders tap the trolley and rail at this point, which is the only distributing point for the entire trolley system. There are section breaks and switches for isolating particular sections of the trolley wires in case of accidents, but normally the trolley wires are continuous from the limits of the Port Huron yards through the tunnel to the limits of the Sarnia yards, a distance of 3.7 miles.

In addition to the locomotive feeders there are two feeders for the tunnel lights, two feeders for the Port Huron portal pump groups, two for the Sarnia portal pump groups, a three-phase power feeder and an arc light feeder for the Port Huron yards and similar feeders for the Sarnia yards. These cables are carried through the tunnel in ducts which are supported by reinforced concrete beams and secured to the lining of the tunnel shell. There are two of these beams, one on each side of the tunnel. The ducts are covered with a three-inch layer of concrete. The feeders are paper insulated lead covered cables and terminate at the pump house switchboards, from which point the arc circuit and the three-phase power circuit continue as bare overhead wires.

In the yards a single catenary trolley construction is used. The spacing of the supporting bridges is 250 feet. There are no obstructions in the nature of intermediate supports, consequently where a number of parallel tracks are electrified the spans are long, as at the Port Huron passenger station where one of the spans is a little in excess of one hundred and forty-three feet. The bridges are tied together with guy cables. This enables a lighter construction to be used than if each bridge were sufficiently rigid, without the use of guy cables, to withstand the unbalanced strain resulting from the breaking of several messenger cables and trolley wires. The trolley wires are twenty-two feet above the tracks except in the tunnel and a short distance outside each portal.

In the tunnel a modification of the catenary construction is used. There are two parallel messenger cables and two parallel trolley wires. The messenger cables are supported on barrel type insulators spaced at intervals of twelve feet. These messengers carry the special double trolley hangers which are also spaced at intervals of twelve feet, but located three feet from the middle of the messenger span. This arrangement gives the required flexibility and at the same time avoids a dangerous vertical displacement of the messenger cables when the pantagraph bow passes under the trolley hanger. The clearance between the messenger cables and the tunnel shell is three inches. The trolley wires are six inches below the messengers which gives a minimum clearance of fifteen feet five inches between the trolley wires and the rail.

The tunnel is damp throughout a considerable portion of its length, consequently there was some doubt as to the advisability of attempting to carry 3,300 volt bare wires within three inches of the cast iron shell. Any fears that may have been entertained have proved to be groundless, for but two insulators have failed since the electric locomotives were put in operation. The weak insulators were eliminated before the service was inaugurated by the use of breakdown tests which were continued until the overhead construction withstood a pressure of 4,500 volts.

The tunnel is well lighted by 480 incandescent lights. These lamps are placed in two rows, one row on either side of the tunnel. They are spaced every twenty-five feet, but as they are staggered there is a lamp for every twelve and a half feet of tunnel length. Since the voltage of the lighting circuit is 440 volts, the lamps are grouped four in series.

On account of the frequency, 25 cycles, it was impossible to use alternating-current arc lights, consequently a mercury converter was installed. There are two loops from the power sta-

tion, one of which is for the Port Huron lights and the other for the Sarnia lights.

DISPATCHING.—The tunnel division is protected by a block signal system which extends from summit to summit. The dispatcher's cabin is located at the Sarnia summit and the other signal cabin at the Port Huron summit. Telegraph orders are used. In addition to the written order the conductor receives a staff when the train enters the block. The switches and signals are locked until this staff is placed in the instrument at the other end of the block. The protection is so complete that not a single accident chargeable to dispatching has occurred during the eighteen years of tunnel service. There is a yard telephone system and in addition a special telephone line connecting the power station, the two signal cabins at the two portals, the middle of the

SINGLE PHASE ELECTRICAL LOCOMOTIVE—ST. CLAIR TUNNEL CO.

tunnel and the roundhouse. The dispatcher is the master of the situation. He not only controls the train movements but the motive power as well. Any failure of power is immediately reported to him. In case it is trouble with a locomotive he has the engine replaced. In case it is trouble with the distributing system he orders the power cut off, then communicates with the electrical superintendent who takes charge of the repairs. As soon as the repairs have been effected the dispatcher is advised and orders the power turned on again. He is also advised as to any power station trouble that will interfere with train movements. There is no division of responsibility. This arrangement is the logical one, since it is the dispatcher's business to get the trains through the tunnel. He must accordingly be supplied with the necessary motive power and be kept advised as to its availability. Likewise in case of trouble on the line he must protect the repairmen by keeping the power off until the proper authority has advised him that power can be turned on again.

LOCOMOTIVES.—Three locomotives have been provided, each consisting of two half-units, each half-unit being mounted on three axles driven through gearing by three single phase motors with a nominal rating of 250 h.p. each. Since the motors have a very liberal overload capacity, it is possible to develop 2,000 h.p. in one locomotive. The half-units are duplicates in every respect, and as the multiple unit system of control is used, they can be operated when coupled together with the same facility as when separate.

As previously stated, the locomotives are designed to develop a drawbar pull of 50,000 pounds at the comparatively low speed of ten miles per hour. The locomotives are powerful enough to start a 1,000-ton train on a 2 per cent. grade in case this should be necessary. At a test made on a half-unit, using a dynamometer car, it was found that a single half-unit developed 43,000 pounds drawbar pull before slipping the wheels. This was done on a comparatively dry rail with a liberal use of sand. On this basis it would be possible to develop about 86,000 pounds drawbar pull with a complete locomotive. The maximum speed of the locomotives is 35 miles per hour. It is not, however, the intention of the Tunnel Company to operate the locomotives at a speed in excess of 30 miles per hour, at which the locomotive will give a tractive effort of 6,000 lbs. Speed indicators are provided, which indicate on a large dial located in the locomotive cab near the engine driver's seat the speed at which the locomotive is running, and at the same time record the speed throughout the length of the run.

The frames of the locomotives are of the rigid outside bar type, and consist essentially of two cast steel side frames joined at the ends by heavy cast steel bumper girders and reinforced by cross braces at two intermediate points. The main journal boxes are carried in the side frames in pedestals fitted with shoes and wedges.

The three pairs of driving wheels, 62 inches in diameter, are built up with cast steel centers and steel tires secured in place by double "Mansel" retaining rings. The total weight of the locomotive rests on the drivers.

The cab is a superstructure of sheet steel with a Z-bar frame built up on an angle iron base frame. The auxiliary apparatus is arranged on each side of the cab leaving a wide aisle down the center. Trap doors are provided in the floor to render access to the motors easy. The locomotives are double ended, that is, a master controller and set of brake valves are mounted at each end of the cab so that the locomotive can be operated from either end. The apparatus in the cab is so laid out that any part can be readily inspected and replaced if necessary.

MOTOR EQUIPMENT.—The motors are of the ten-pole compensated type and are designed to operate at a normal voltage of 235 volts at a frequency of 25 cycles. They are connected in multiple and are so arranged that any one or two motors can be disconnected in case of trouble. The cut-out switches are designated by numbers and are mounted on the end of the reverse group. The motors are provided with air inlets, and ducts of ample size lead to these inlets from a blower so that forced ventilation can be effectively used. The blower also supplies air to ventilate the main auto-transformer. The continuous capacity of the motors under forced ventilation is 750 amperes at 235 volts. This rating would permit two half-units to pull a 2,500-ton train at a constant speed of 15½ m.p.h. for any desired length of time on a straight level track.

CONTROL AND AUXILIARIES.—The essential parts of the control system in each half-unit are: one 3,300 volt auto-transformer, three preventive coils, a train line relay, three switch groups, two master controllers, two small storage batteries and a small motor-generator set.

The main auto-transformer is located on the right side of the cab in the center. It is connected to the trolley by a high-tension cable through an oil circuit breaker provided with a no-voltage release protective relay. In case the locomotive should leave the rails and the frame thus become insulated from ground, this relay would cause the circuit breaker to open and remain open until the ground connection to the locomotive frame becomes re-established.

The preventive coils, three in number, are located directly over the blower in the No. 1 end of the cab and provide a means of stepping from one transformer tap to another without producing a short-circuit in the transformer or an open circuit to the motors. At the same time they serve to distribute the motor current among the four switches in the transformer switch groups.

The train line relay is located between the transformer switch groups, its purpose being to enable a number of the wires leading from the master controllers to be used twice, thus cutting down the number of control wires required between half-units when operating in pairs, and at the same time shortening the length of the controller drum.

There are three switch groups, two being transformer groups and the third the reverser group. The transformer groups are located above the transformer with the train line relay between them. Each group consists of ten electro-pneumatically operated switches. The function of these groups is to connect the motors to the various taps on the auto-transformer to give the requisite speed regulation. As these switch groups are very close to the

Sarnia, as well as for a small amount of arc lighting.

Power Station.—The power station is situated on the Port Huron bank of the river, at a point almost directly over the tunnel. The building construction is of concrete to the dynamo room floor. The walls above this point are continued with paving brick and are corniced and coped with concrete. The roof is of cinder concrete. The dynamo room is lofty and well lighted. The walls are lined with enamel brick to the height of the switchboard, the remaining portion being lined with sand lime brick. The basement has plenty of head room and contains the condenser pump groups and stoker fan groups. The dynamo room floor is so recessed that the auxiliary apparatus in the basement is in view from the dynamo room floor. The boiler room floor is on the same level as the dynamo room basement floor. A striking feature of the boiler room is the reinforced concrete coal bunker. This extends the entire length of the boiler room, and has a capacity of 500 tons.

The power station equipment is in duplicate. There are two 1,250 kw., three-phase, 25-cycle, 3,300 volt turbo-generators, either of which is capable of handling the maximum demand upon the station. Each turbine has its independent barometric condenser. There are two steam driven exciters and a motor driven exciter group. The momentary peak loads have reached 2,400 kw., single-phase, and a Tirrill regulator has been provided to keep the voltage of the locomotive phase uniform over the entire range of load. There is in addition to the locomotive load a small three-phase load consisting of power house motors, drainage pump motors and roundhouse motors. The incandescent lighting is connected to same phase as the locomotives.

Since there is but a single track in the tunnel, there can be only one train on the grade at a time, consequently the load is an extremely variable one. The plant has been designed to meet this condition. The turbines have a large overload capacity and the boilers have extra large steam drum capacity. The four boilers have a nominal rating of 400 h.p. each, and each boiler has three steam drums. Ordinarily there are three boilers in use, although two are sufficient to care for the average load. Steam is kept up in the third boiler in order to avoid the delay which would occur in getting it into commission in case of an accident to an active boiler. When there is a drop in boiler pressure due to a heavy overload the speed of the forced draft fan engine is automatically increased, and at the same time the fuel supply to the underfeed stokers is automatically increased by the speeding up of the stoker feeding mechanism. The nominal boiler pressure is 200 pounds and the nominal turbine pressure is 175 pounds, consequently some drop in steam pressure is allowable, but the automatic action of the stokers is such as to keep the drop from becoming excessive. The separately fired superheater is of a type that has considerable heat storage capacity. The temperature is controlled by the means of dampers, which are automatically operated by a water piston whose valves are operated by an electro-magnet primarily controlled by a thermo-couple in the steam line. The automatic control is arranged for a low uniform superheat in order that there may be no wide variation of temperature in the exhaust portion of the turbine when a heavy change in load occurs. High pressure superheated steam is used in the turbine alone. An auxiliary steam line, tapped off between the boilers and the superheater and equipped with reducing valves, delivers low pressure saturated steam to the auxiliaries. The auxiliaries exhaust into a feed water heater. The boiler feed pumps draw their water supply from the condenser discharge.

The station was put in commission November, 1907, at which time it was thoroughly tested out with an artificial load that corresponded to actual service conditions. Later it was subjected to an official test and was found to more than meet the contract guarantees. The station has been operated from the start by the Tunnel Company's employees, although during the preliminary operating period the operation was nominally in the hands of the contractors. The station, while it is a simple one, contains refinements that good engineering demands. The load factor is necessarily bad, which fact, of course, is not conducive to economy. But the station has been designed to meet the tunnel conditions, and its economy is all that can be expected with a single track heavy grade freight load.

Distributing System.—Just outside the power station there is a vertical shaft which extends to the tunnel. A reinforced concrete duct chimney has been built in this shaft as a continuation of the power station duct lines. All the feeders pass from this chimney through holes in the tunnel shell into the tunnel. The locomotive feeders tap the trolley and rail at this point, which is the only distributing point for the entire trolley system. There are section breaks and switches for isolating particular sections of the trolley wires in case of accidents, but normally the trolley wires are continuous from the limits of the Port Huron yards through the tunnel to the limits of the Sarnia yards, a distance of 3.7 miles.

In addition to the locomotive feeders there are two feeders for the tunnel lights, two feeders for the Port Huron portal pump groups, two for the Sarnia portal pump groups, a three-phase power feeder and an arc light feeder for the Port Huron yards and similar feeders for the Sarnia yards. These cables are carried through the tunnel in ducts which are supported by reinforced concrete beams and secured to the lining of the tunnel shell. There are two of these beams, one on each side of the tunnel. The ducts are covered with a three-inch layer of concrete. The feeders are paper insulated lead covered cables and terminate at the pump house switchboards, from which point the arc circuit and the three-phase power circuit continue as bare overhead wires.

In the yards a single catenary trolley construction is used. The spacing of the supporting bridges is 250 feet. There are no obstructions in the nature of intermediate supports, consequently where a number of parallel tracks are electrified the spans are long, as at the Port Huron passenger station where one of the spans is a little in excess of one hundred and forty-three feet. The bridges are tied together with guy cables. This enables a lighter construction to be used than if each bridge were sufficiently rigid, without the use of guy cables, to withstand the unbalanced strain resulting from the breaking of several messenger cables and trolley wires. The trolley wires are twenty-two feet above the tracks except in the tunnel and a short distance outside each portal.

In the tunnel a modification of the catenary construction is used. There are two parallel messenger cables and two parallel trolley wires. The messenger cables are supported on barrel type insulators spaced at intervals of twelve feet. These messengers carry the special double trolley hangers which are also spaced at intervals of twelve feet, but located three feet from the middle of the messenger span. This arrangement gives the required flexibility and at the same time avoids a dangerous vertical displacement of the messenger cables when the pantagraph bow passes under the trolley hanger. The clearance between the messenger cables and the tunnel shell is three inches. The trolley wires are six inches below the messengers which gives a minimum clearance of fifteen feet five inches between the trolley wires and the rail.

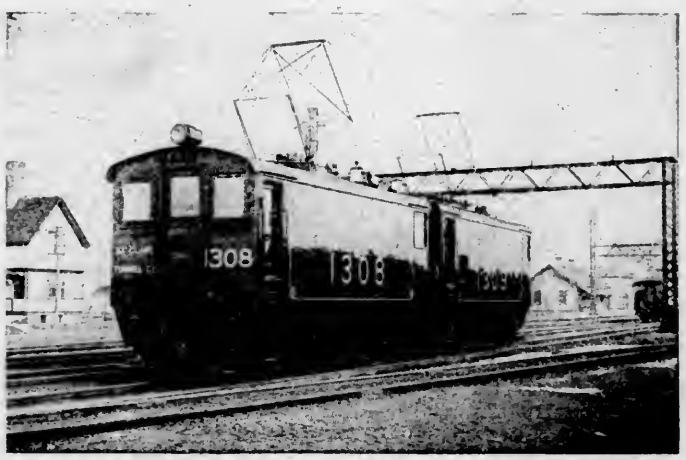
The tunnel is damp throughout a considerable portion of its length, consequently there was some doubt as to the advisability of attempting to carry 3,300 volt bare wires within three inches of the cast iron shell. Any fears that may have been entertained have proved to be groundless, for but two insulators have failed since the electric locomotives were put in operation. The weak insulators were eliminated before the service was inaugurated by the use of breakdown tests which were continued until the overhead construction withstood a pressure of 4,500 volts.

The tunnel is well lighted by 480 incandescent lights. These lamps are placed in two rows, one row on either side of the tunnel. They are spaced every twenty-five feet, but as they are staggered there is a lamp for every twelve and a half feet of tunnel length. Since the voltage of the lighting circuit is 440 volts, the lamps are grouped four in series.

On account of the frequency, 25 cycles, it was impossible to use alternating-current arc lights, consequently a mercury converter was installed. There are two loops from the power sta-

tion, one of which is for the Port Huron lights and the other for the Sarnia lights.

DISPATCHING.—The tunnel division is protected by a block signal system which extends from summit to summit. The dispatcher's cabin is located at the Sarnia summit and the other signal cabin at the Port Huron summit. Telegraph orders are used. In addition to the written order the conductor receives a staff when the train enters the block. The switches and signals are locked until this staff is placed in the instrument at the other end of the block. The protection is so complete that not a single accident chargeable to dispatching has occurred during the eighteen years of tunnel service. There is a yard telephone system and in addition a special telephone line connecting the power station, the two signal cabins at the two portals, the middle of the



SINGLE-PHASE ELECTRICAL LOCOMOTIVE—ST. CLAIR TUNNEL CO.

tunnel and the roundhouse. The dispatcher is the master of the situation. He not only controls the train movements but the motive power as well. Any failure of power is immediately reported to him. In case it is trouble with a locomotive he has the engine replaced. In case it is trouble with the distributing system he orders the power cut off, then communicates with the electrical superintendent who takes charge of the repairs. As soon as the repairs have been effected the dispatcher is advised and orders the power turned on again. He is also advised as to any power station trouble that will interfere with train movements. There is no division of responsibility. This arrangement is the logical one, since it is the dispatcher's business to get the trains through the tunnel. He must accordingly be supplied with the necessary motive power and be kept advised as to its availability. Likewise in case of trouble on the line he must protect the repairmen by keeping the power off until the proper authority has advised him that power can be turned on again.

LOCOMOTIVES.—Three locomotives have been provided, each consisting of two half-units, each half-unit being mounted on three axles driven through gearing by three single phase motors with a nominal rating of 250 h.p. each. Since the motors have a very liberal overload capacity, it is possible to develop 2,000 h.p. in one locomotive. The half-units are duplicates in every respect, and as the multiple unit system of control is used, they can be operated when coupled together with the same facility as when separate.

As previously stated, the locomotives are designed to develop a drawbar pull of 50,000 pounds at the comparatively low speed of ten miles per hour. The locomotives are powerful enough to start a 1,000-ton train on a 2 per cent. grade in case this should be necessary. At a test made on a half-unit, using a dynamometer car, it was found that a single half-unit developed 43,000 pounds drawbar pull before slipping the wheels. This was done on a comparatively dry rail with a liberal use of sand. On this basis it would be possible to develop about 86,000 pounds drawbar pull with a complete locomotive. The maximum speed of the locomotives is 35 miles per hour. It is not, however, the intention of the Tunnel Company to operate the locomotives at a speed in excess of 30 miles per hour, at which the locomotive will give a tractive effort of 6,000 lbs. Speed indicators are provided, which indicate on a large dial located in the locomotive cab near the engine driver's seat the speed at which the locomotive is running, and at the same time record the speed throughout the length of the run.

The frames of the locomotives are of the rigid outside bar type, and consist essentially of two cast steel side frames joined at the ends by heavy cast steel bumper girders and reinforced by cross braces at two intermediate points. The main journal boxes are carried in the side frames in pedestals fitted with shoes and wedges.

The three pairs of driving wheels, 62 inches in diameter, are built up with cast steel centers and steel tires secured in place by double "Mansel" retaining rings. The total weight of the locomotive rests on the drivers.

The cab is a superstructure of sheet steel with a Z-bar frame built up on an angle iron base frame. The auxiliary apparatus is arranged on each side of the cab leaving a wide aisle down the center. Trap doors are provided in the floor to render access to the motors easy. The locomotives are double ended, that is, a master controller and set of brake valves are mounted at each end of the cab so that the locomotive can be operated from either end. The apparatus in the cab is so laid out that any part can be readily inspected and replaced if necessary.

MOTOR EQUIPMENT.—The motors are of the ten-pole compensated type and are designed to operate at a normal voltage of 235 volts at a frequency of 25 cycles. They are connected in multiple and are so arranged that any one or two motors can be disconnected in case of trouble. The cut-out switches are designated by numbers and are mounted on the end of the reverse group. The motors are provided with air inlets, and ducts of ample size lead to these inlets from a blower so that forced ventilation can be effectively used. The blower also supplies air to ventilate the main auto-transformer. The continuous capacity of the motors under forced ventilation is 750 amperes at 235 volts. This rating would permit two half-units to pull a 2,500-ton train at a constant speed of 15½ m.p.h. for any desired length of time on a straight level track.

CONTROL AND AUXILIARIES.—The essential parts of the control system in each half-unit are: one 3,300 volt auto-transformer, three preventive coils, a train line relay, three switch groups, two master controllers, two small storage batteries and a small motor-generator set.

The main auto-transformer is located on the right side of the cab in the center. It is connected to the trolley by a high-tension cable through an oil circuit breaker provided with a no-voltage release protective relay. In case the locomotive should leave the rails and the frame thus become insulated from ground, this relay would cause the circuit breaker to open and remain open until the ground connection to the locomotive frame becomes re-established.

The preventive coils, three in number, are located directly over the blower in the No. 1 end of the cab and provide a means of stepping from one transformer tap to another without producing a short-circuit in the transformer or an open circuit to the motors. At the same time they serve to distribute the motor current among the four switches in the transformer switch groups.

The train line relay is located between the transformer switch groups, its purpose being to enable a number of the wires leading from the master controllers to be used twice, thus cutting down the number of control wires required between half-units when operating in pairs, and at the same time shortening the length of the controller drum.

There are three switch groups, two being transformer groups and the third the reverser group. The transformer groups are located above the transformer with the train line relay between them. Each group consists of ten electro-pneumatically operated switches. The function of these groups is to connect the motors to the various taps on the auto-transformer to give the requisite speed regulation. As these switch groups are very close to the

transformer, the leads between the two pieces of apparatus are very short. The third switch group is located on the left side of the locomotive and consists of 12 electro-pneumatically operated switches. The switches in this group control the direction in which the locomotive is run. There are four of these switches for each motor, two for operation in the forward direction and two for reversing.

A master controller is located at each end of each half-unit on the right side, so placed that the engineer can have a clear view ahead from his seat and, at the same time, can easily operate the controller and brake valve handles. Each master controller has two interlocking handles; one is the operating handle and the other the reversing handle. The master controller operates the various switches in the switch group by current from a 20-volt storage battery circuit and has 17 running notches and three switching notches. In the operation of the locomotives the controller can be left on any of the running notches, as there is no resistance to overheat and burn out. This gives the alternating-current locomotive a very distinct advantage over the direct-current type where only two or three running notches are available. The switching notches are used only for running the locomotive without load at low speed, as when passing over switches and frogs in the yards, and are passed over when handling a load. The engineer is guided in the operation of the controller by an ammeter mounted directly before him in the cab. In case the engineer operates his controller too fast, the circuit breaker will open and cannot be reset until he has thrown the controller handle to the "off" position. The circuit breakers on the locomotives are normally set to open when a current exceeding 4,500 amperes is taken by the motors. Across the top of the controller are located a number of push buttons which, when pressed, operate respectively the pneumatic bell ringer, pneumatic sanders, circuit breaker reset, and pantagraph trolley. Foot pedals are placed within convenient reach of the engineer's foot which also serve to operate the bell and sanders. The general principle of the operation of the control system is as follows: Air cylinders are used to operate the various switches and low voltage magnet valves to control the supply of air to the various switches. Two or more locomotives may be operated as one unit from any controller by inserting the proper "jumpers" between locomotives.

The ten cell (20 volts) storage batteries provided to operate the control magnets are in duplicate, one being in use while the other is being charged. The charging is done by means of the small 100 watt motor-generator set previously mentioned.

The air compressor is located beside the main reservoir on the left side. The maximum pressure used is 100 lbs., gauge pressure. A reducing valve lowers the pressure to 80 lbs. for use in the control system. The blower is located on the left side under the preventive coils. Both the compressor and blower motors are operated from low voltage taps on the main auto-transformer. In addition to the ammeters at each end of the locomotive a "motor" voltmeter, a "line" integrating wattmeter, and a "motor" indicating wattmeter are provided and are located on the left side of the locomotive above the reversing switch group.

The current is collected from the trolley wires by means of a sliding bow pantograph trolley. In so far as the trolley wire extends throughout the length of the tunnel, no additional provision has to be made for the collection of current while the locomotive is passing through the tunnel. Electric headlights are provided, as well as lights for the illumination of the interior of the cab and the dials of the indicating instruments. The heating of the cabs is provided for by means of standard electric heaters. Heat is also available for drying the sand stored in sand boxes. In general, the M. C. B. standards have been conformed with in so far as couplers, wheel treads, etc., are concerned. The general dimensions of the half-units are as follows:

Length over all	23 ft. 6 in.
Height from top of rail to top of roof	13 ft.
Height from top of rail to top of pantograph bow when lowered	14 ft. 11 in.
Width of cab over all	9 ft. 8 in.
Total weight of locomotive half-unit, fully equipped	67½ tons
(This weight is practically evenly divided over three drivers.)	
Weight of complete locomotive unit	135 tons
Length of rigid wheel base	16 ft.
Diameter of driving wheels	62 in.
Normal speed of train, ascending 2 per cent. grade (miles per hour)	10
Normal speed on level tracks (miles per hour)	25 to 30

In service it has been found that the locomotives will very readily handle a 1,000-ton train at from 11 to 12, and possibly 13 to 14 miles per hour on a 2 per cent. grade, thus demonstrating their ability to more than fulfil the specified performance.

Mr. Bion J. Arnold, who prepared the original specifications for this work, has acted as consulting engineer for the railway company, and as such has had a general supervision of the installation. The contractors were the Westinghouse Electric and Manufacturing Co., who were directly responsible for the installation and successful operation of the entire equipment.

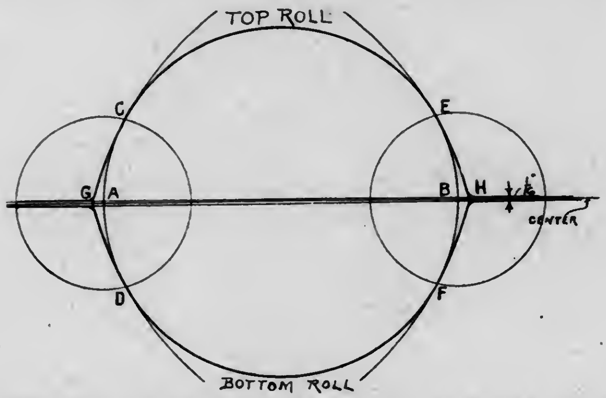
The information in this article has been largely drawn from a pamphlet prepared by F. A. Sager and issued by the general passenger department of the Grand Trunk Railway, and articles by H. L. Kirker, L. M. Aspinwall and C. Bright in *The Electric Journal.*

A SMALL "HAND-AROUND" MILL, ADAPTED TO RAILROAD WORK.

By J. S. Sheafe.*

Railroads are becoming more and more interested in reclaiming what is ordinarily regarded as scrap material. Two or three of the larger roads have obtained splendid results by installing a small rolling mill and reducing scrap rods to a smaller diameter. The illustration shows a "two high" or two roll mill which has been in use in the Burnside shops of the Illinois Central Railroad for the past fourteen months and is similar to one which has been used in the West Milwaukee shops of the Chicago, Milwaukee & St. Paul Railway shops for a long time.

Such a mill may be purchased from any of the rolling mill equipment companies at a cost of one thousand dollars or less, but should preferably be three-high so that the material may be



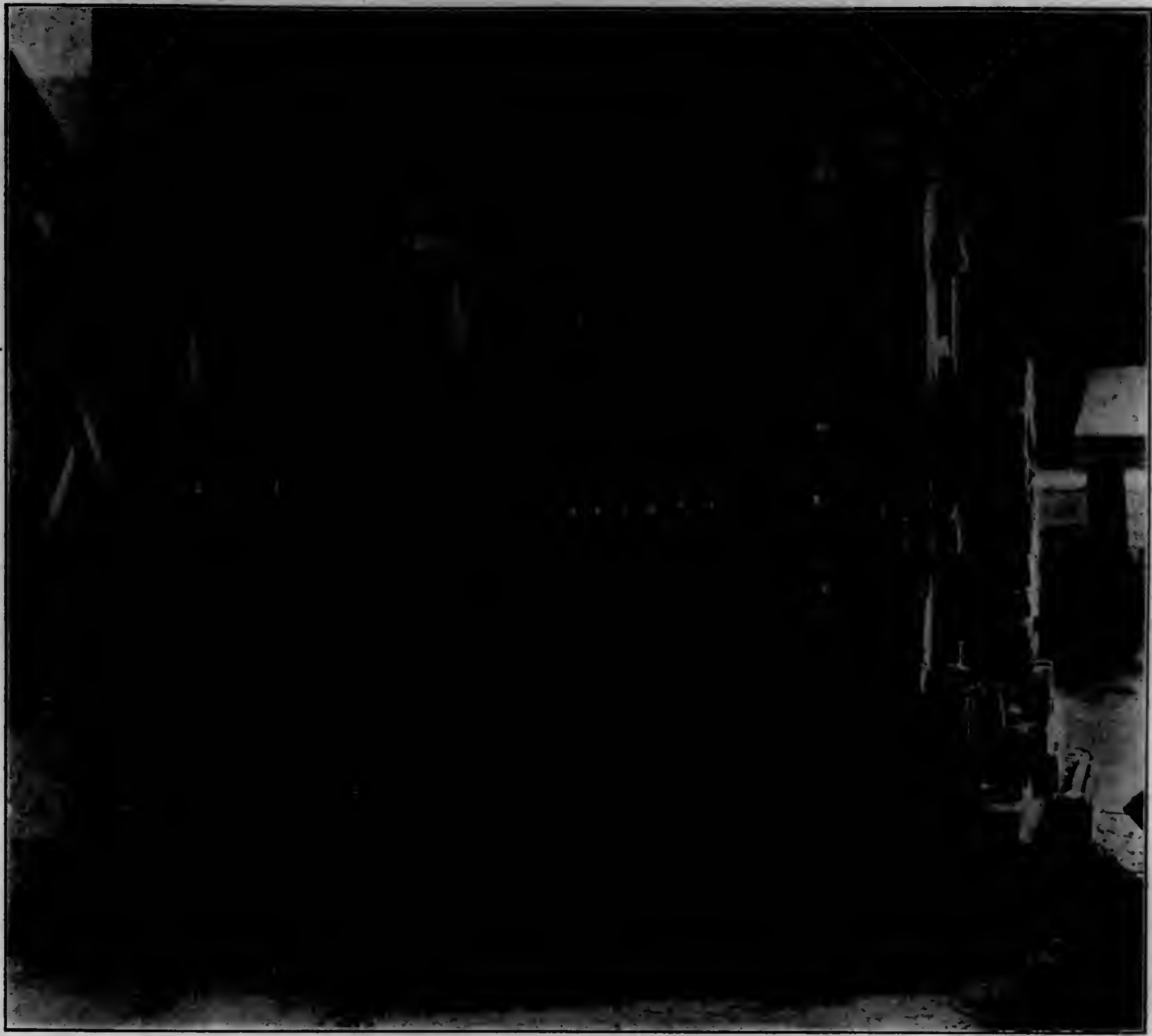
ILLUSTRATING THE METHOD OF LAYING OUT TEMPLATES FOR THE ROLLS.

A B is the diameter of the pass.
One-quarter of A B is taken as a radius and with centers at A and B the circle is cut at C, D, E and F.
With F and D as centers and radii equal to F C and D E the arcs C G and E H are drawn.
The corners at G and H are then chamfered slightly.
G C E H F D is then the contour of the pass.

passed back through the rolls instead of handing it back to the head roller, as is necessary with the two-roll mill.

Scrap iron from 1 to 2¼ ins. in diameter is cut to lengths convenient for handling, heated in a furnace to a soft heat, and passed to the head roller who starts it through the rolls. A man behind the rolls catches the iron and passes it back over the top to the roller, who continues to work the iron down to the size desired. (The three high roll would permit the "catcher" to send it back to the roller through the next pass.) The iron, when down to size, should be up-ended for the finish, after which it is

* Mechanical Inspector, Illinois Central Railroad.



TWO-HIGH ROLLING MILL—ILLINOIS CENTRAL RAILROAD.

passed to the straightening table, straightened while hot, and placed upon a "hot bed," ~~or~~ any level surface, to cool. The pieces when finished vary from 5 to 8 feet in length, according to the size of the billet; the waste from short ends, in cutting to length, is surprisingly low.

The passes are from 2⅛ to ¾ ins. round and are reduced by ⅛ in. to the ⅞ in. pass, after which the reduction is 1/16 in., it having been found that ⅛ in. draw is too much for the small sizes. The limit of size is ¾ in., as the labor required to further reduce it overbalances the profit, in addition to the difficulty of holding it up to secure a round cross-section.

The rolls are made of charcoal iron, and may be turned up in any heavy lathe. The "neck," or bearing is turned from a center, after which the rolls are put in bearings and the passes turned while thus supported. The passes are made perfectly round by means of a thimble, which rests against a forked piece, which in turn is held in the tool post.

The round passes are further finished to templates; the accompanying sketch illustrates the manner of making these. The iron, in being reduced, must have some space into which to flow and the object of the form furnished by the template is to provide this space and still preserve the general form for the next smaller pass; 1/32 in. is taken from each roll, thereby allowing them to be separated 1/16 in. when set up. This means that the diameter of each roll is reduced 1/16 in. and this operation should be performed after the passes are in, so that they will not be off-size when the rolls are together. One of the templates should be made for at least each of the finished sizes of iron, *i. e.*, ¾, ⅞, 1, and 1⅛ in.; the other sizes are of less importance, so long as part of the pass is cut away to the general form of the template.

Through the rolls may be seen the guides, one at each pass, whose function it is to pick up the iron as it comes through. The top roll, being ⅛ in. larger in diameter than the bottom one, naturally holds the iron down against the guides.

As high as 6,500 pounds of iron have been sent through these rolls in nine hours at a labor cost of $12.50 and $2.00 for fuel. This, of course, is the high-water mark, but the average daily output, with a good set of men, on a piecework basis, would nearly equal these figures.

REPAIR OF CRACKS AND BLOW HOLES IN CASTINGS.

A large amount of money is spent every year replacing machinery and parts, automobile cylinders, castings, radiators, boilers, fire pots, pipes and many other things which have become useless because of cracks, spongy spots, sand holes or blow holes. There is hardly a factory of any size which does not contribute something to this scrap heap every year because it is not possible to repair such defects in iron and steel.

A new compound which has recently been placed on the market by H. W. Johns-Manville Company, New York, is claimed to make repairs of this kind perfectly. It is called "Leak-No Metallic Compound" and is a chemical composition resembling powdered iron. When mixed with water and applied like putty to defects in iron or steel articles it metalizes and is said to become a permanent part of the article to which it is applied. The manufacturers guarantee it to stop any ordinary leak against any pressure in anything made of iron or steel. It will also stand any heat that iron will stand. If this compound comes up to the claims it certainly will prove to be a great boon to all manufacturers.

transformer, the leads between the two pieces of apparatus are very short. The third switch group is located on the left side of the locomotive and consists of 12 electro-pneumatically operated switches. The switches in this group control the direction in which the locomotive is run. There are four of these switches for each motor, two for operation in the forward direction and two for reversing.

A master controller is located at each end of each half-unit on the right side, so placed that the engineer can have a clear view ahead from his seat and, at the same time, can easily operate the controller and brake valve handles. Each master controller has two interlocking handles; one is the operating handle and the other the reversing handle. The master controller operates the various switches in the switch group by current from a 20-volt storage battery circuit and has 17 running notches and three switching notches. In the operation of the locomotives the controller can be left on any of the running notches, as there is no resistance to overheat and burn out. This gives the alternating-current locomotive a very distinct advantage over the direct-current type where only two or three running notches are available. The switching notches are used only for running the locomotive without load at low speed, as when passing over switches and frogs in the yards, and are passed over when handling a load. The engineer is guided in the operation of the controller by an ammeter mounted directly before him in the cab. In case the engineer operates his controller too fast, the circuit breaker will open and cannot be reset until he has thrown the controller handle to the "off" position. The circuit breakers on the locomotives are normally set to open when a current exceeding 4,500 amperes is taken by the motors. Across the top of the controller are located a number of push buttons which, when pressed, operate respectively the pneumatic bell ringer, pneumatic sanders, circuit breaker reset, and pantagraph trolley. Foot pedals are placed within convenient reach of the engineer's foot which also serve to operate the bell and sanders. The general principle of the operation of the control system is as follows: Air cylinders are used to operate the various switches and low voltage magnet valves to control the supply of air to the various switches. Two or more locomotives may be operated as one unit from any controller by inserting the proper "jumpers" between locomotives.

The ten cell (20 volts) storage batteries provided to operate the control magnets are in duplicate, one being in use while the other is being charged. The charging is done by means of the small 100 watt motor-generator set previously mentioned.

The air compressor is located beside the main reservoir on the left side. The maximum pressure used is 100 lbs., gauge pressure. A reducing valve lowers the pressure to 80 lbs. for use in the control system. The blower is located on the left side under the preventive coils. Both the compressor and blower motors are operated from low voltage taps on the main auto-transformer. In addition to the ammeters at each end of the locomotive a "motor" voltmeter, a "line" integrating wattmeter, and a "motor" indicating wattmeter are provided and are located on the left side of the locomotive above the reversing switch group.

The current is collected from the trolley wires by means of a sliding bow pantograph trolley. In so far as the trolley wire extends throughout the length of the tunnel, no additional provision has to be made for the collection of current while the locomotive is passing through the tunnel. Electric headlights are provided, as well as lights for the illumination of the interior of the cab and the dials of the indicating instruments. The heating of the cabs is provided for by means of standard electric heaters. Heat is also available for drying the sand stored in sand boxes. In general, the M. C. B. standards have been conformed with in so far as couplers, wheel treads, etc., are concerned. The general dimensions of the half units are as follows:

Length over all	23 ft. 6 in.
Height from top of rail to top of roof	13 ft.
Height from top of rail to top of pantograph bow when lowered	14 ft. 11 in.
Width of cab over all	9 ft. 8 in.
Total weight of locomotive half-unit, fully equipped	67½ tons
(This weight is practically evenly divided over three drivers.)	
Weight of complete locomotive unit	135 tons
Length of rigid wheel base	16 ft.
Diameter of driving wheels	62 in.
Normal speed of train, ascending 2 per cent. grade (miles per hour)	10
Normal speed on level tracks (miles per hour)	25 to 30

In service it has been found that the locomotives will very readily handle a 1,000-ton train at from 11 to 12, and possibly 13 to 14 miles per hour on a 2 per cent. grade, thus demonstrating their ability to more than fulfil the specified performance.

Mr. Bion J. Arnold, who prepared the original specifications for this work, has acted as consulting engineer for the railway company, and as such has had a general supervision of the installation. The contractors were the Westinghouse Electric and Manufacturing Co., who were directly responsible for the installation and successful operation of the entire equipment.

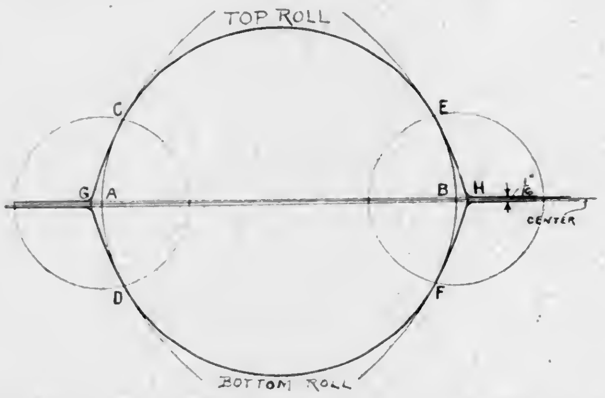
The information in this article has been largely drawn from a pamphlet prepared by F. A. Sager and issued by the general passenger department of the Grand Trunk Railway, and articles by H. L. Kirker, L. M. Aspinwall and C. Bright in *The Electric Journal.*

A SMALL "HAND-AROUND" MILL, ADAPTED TO RAILROAD WORK.

By J. S. Sheafe.*

Railroads are becoming more and more interested in reclaiming what is ordinarily regarded as scrap material. Two or three of the larger roads have obtained splendid results by installing a small rolling mill and reducing scrap rods to a smaller diameter. The illustration shows a "two high" or two roll mill which has been in use in the Burnside shops of the Illinois Central Railroad for the past fourteen months and is similar to one which has been used in the West Milwaukee shops of the Chicago, Milwaukee & St. Paul Railway shops for a long time.

Such a mill may be purchased from any of the rolling mill equipment companies at a cost of one thousand dollars or less, but should preferably be three-high so that the material may be



ILLUSTRATING THE METHOD OF LAYING OUT TEMPLATES FOR THE ROLLS.

A B is the diameter of the pass.

One-quarter of A B is taken as a radius and with centers at A and B the circle is cut at C, D, E and F.

With F and D as centers and radii equal to F C and D E the arcs C G and E H are drawn.

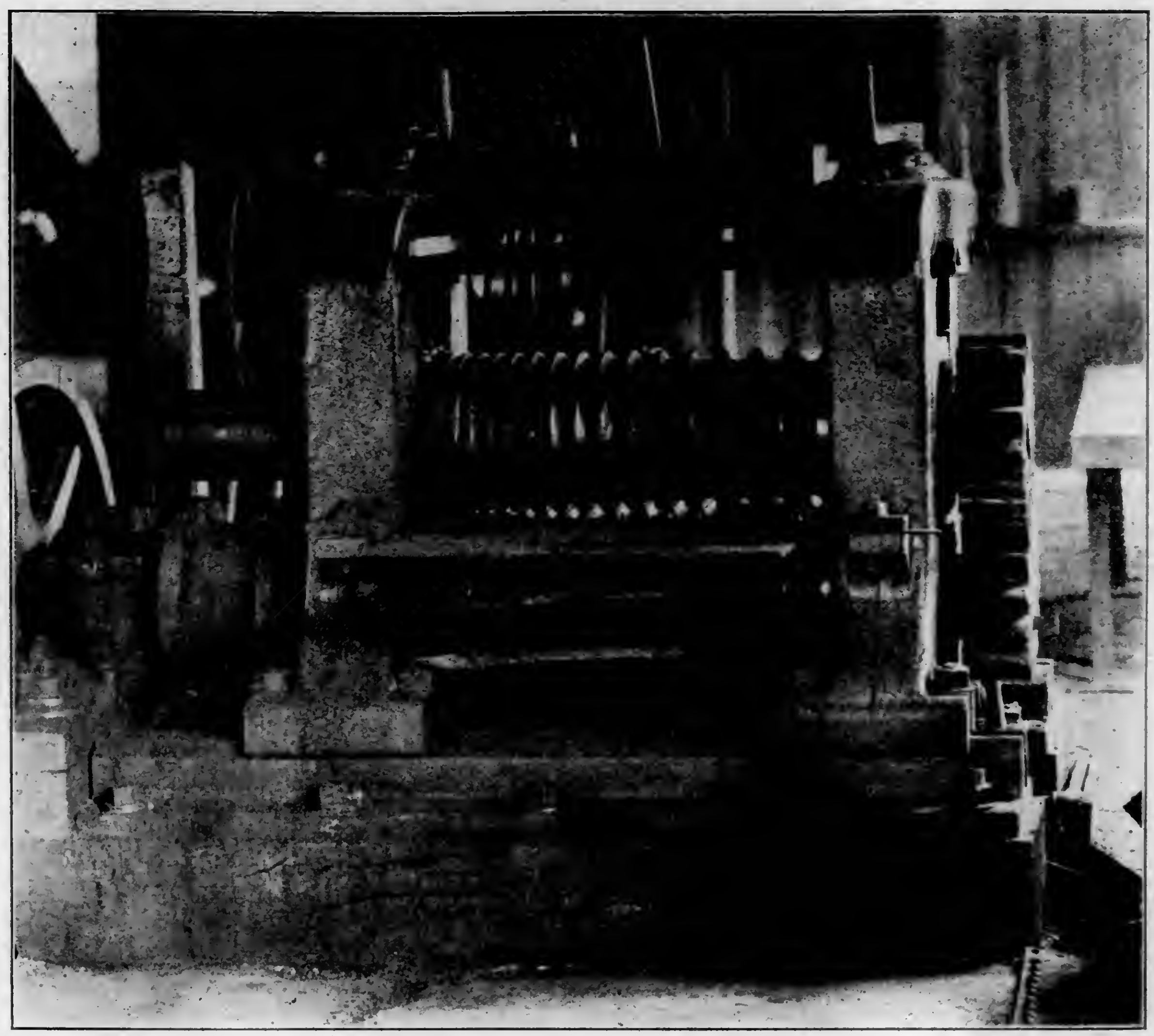
The corners at G and H are then chamfered slightly.

G C E H F D is then the contour of the pass.

passed back through the rolls instead of handing it back to the head roller, as is necessary with the two-roll mill.

Scrap iron from 1 to 2¼ ins. in diameter is cut to lengths convenient for handling, heated in a furnace to a soft heat, and passed to the head roller who starts it through the rolls. A man behind the rolls catches the iron and passes it back over the top to the roller, who continues to work the iron down to the size desired. (The three high roll would permit the "catcher" to send it back to the roller through the next pass.) The iron, when down to size, should be up-ended for the finish, after which it is

* Mechanical Inspector, Illinois Central Railroad.



TWO-HIGH ROLLING MILL—ILLINOIS CENTRAL RAILROAD.

passed to the straightening table, straightened while hot, and placed upon a "hot bed," or any level surface, to cool. The pieces when finished vary from 5 to 8 feet in length, according to the size of the billet; the waste from short ends, in cutting to length, is surprisingly low.

The passes are from 2⅛ to ¾ ins. round and are reduced by ⅛ in. to the ⅞ in. pass, after which the reduction is 1/16 in., it having been found that ⅛ in. draw is too much for the small sizes. The limit of size is ¾ in., as the labor required to further reduce it overbalances the profit, in addition to the difficulty of holding it up to secure a round cross-section.

The rolls are made of charcoal iron, and may be turned up in any heavy lathe. The "neck," or bearing is turned from a center, after which the rolls are put in bearings and the passes turned while thus supported. The passes are made perfectly round by means of a thimble, which rests against a forked piece, which in turn is held in the tool post.

The round passes are further finished to templates; the accompanying sketch illustrates the manner of making these. The iron, in being reduced, must have some space into which to flow and the object of the form furnished by the template is to provide this space and still preserve the general form for the next smaller pass; 1/32 in. is taken from each roll, thereby allowing them to be separated 1/16 in. when set up. This means that the diameter of each roll is reduced 1/16 in. and this operation should be performed after the passes are in, so that they will not be off-size when the rolls are together. One of the templates should be made for at least each of the finished sizes of iron, *i. e.*, ¾, ⅞, 1, and 1⅛ in.; the other sizes are of less importance, so long as part of the pass is cut away to the general form of the template.

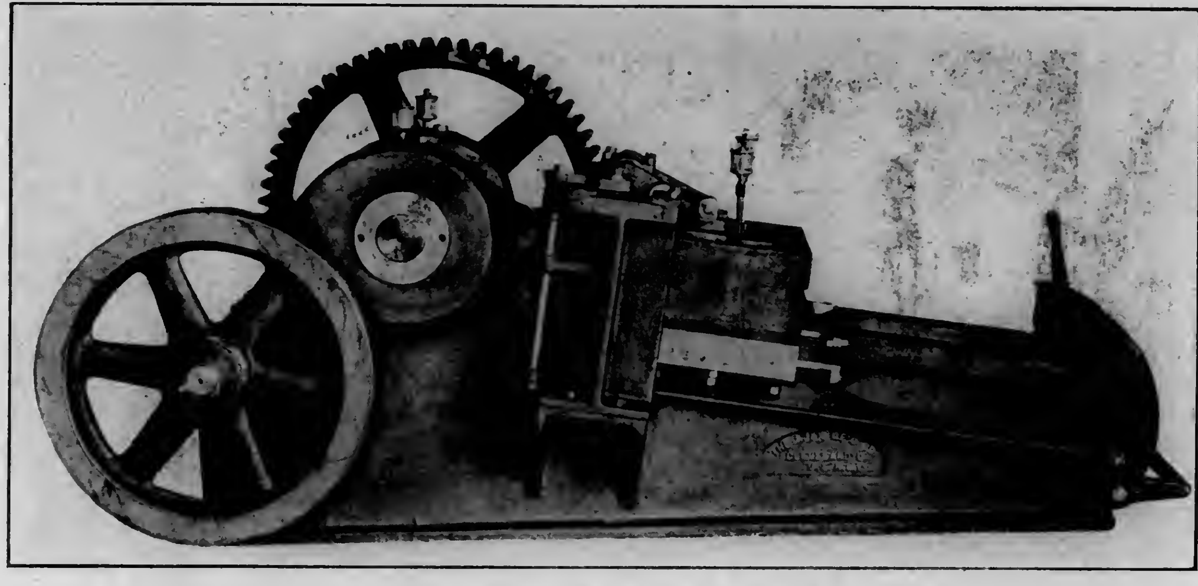
Through the rolls may be seen the guides, one at each pass, whose function it is to pick up the iron as it comes through. The top roll, being ⅛ in. larger in diameter than the bottom one, naturally holds the iron down against the guides.

As high as 6,500 pounds of iron have been sent through these rolls in nine hours at a labor cost of $12.50 and $2.00 for fuel. This, of course, is the high-water mark, but the average daily output, with a good set of men, on a piecework basis, would nearly equal these figures.

REPAIR OF CRACKS AND BLOW HOLES IN CASTINGS.

A large amount of money is spent every year replacing machinery and parts, automobile cylinders, castings, radiators, boilers, fire pots, pipes and many other things which have become useless because of cracks, spongy spots, sand holes or blow holes. There is hardly a factory of any size which does not contribute something to this scrap heap every year because it is not possible to repair such defects in iron and steel.

A new compound which has recently been placed on the market by H. W. Johns-Manville Company, New York, is claimed to make repairs of this kind perfectly. It is called "Leak-No Metallic Compound" and is a chemical composition resembling powdered iron. When mixed with water and applied like putty to defects in iron or steel articles it metalizes and is said to become a permanent part of the article to which it is applied. The manufacturers guarantee it to stop any ordinary leak against any pressure in anything made of iron or steel. It will also stand any heat that iron will stand. If this compound comes up to the claims it certainly will prove to be a great boon to all manufacturers.



AJAX HIGH SPEED STOP MOTION BULLDOZER.

HIGH SPEED, STOP MOTION BULLDOZER.

A new style bending machine, known as a high speed, stop motion bulldozer, and embodying a number of improvements over the old style, slow motion machines, has recently been placed on the market by the Ajax Manufacturing Company of Cleveland. It is specially designed for bending work cold. These machines are being manufactured in six sizes, from No. 1 to No. 6; the general dimensions of the largest and smallest and one of the intermediate sizes are given in the following table:

	No. 1	No. 3	No. 6
Floor space	5′ x 2′ 2″	10′ x 3′ 6″	15′ x 7′ 6″
Face of crosshead	16″ x 4″	28″ x 8″	60″ x 10″
Travel of crosshead	5″ to 8″	5″ to 10″	5″ to 14″
Travel of crosshead, std	5″	8″	10″
Approximate weight of machine	2,200 lbs.	9,500 lbs.	24,000 lbs.

A ⅝ x 3 in. arch bar, with a set of 8 in., was recently bent cold in a No. 3 machine; the four bends were easily made in one operation.

The most important features of the new machine are the rapid movement of the crosshead and the control which the operator has over it at all times. The crosshead makes 60 strokes per minute for the No. 1 size and 45 strokes per minute for the No. 6, or largest size. The machine may be thrown into operation by either a foot pedal or a hand lever, which causes the crosshead to make a complete stroke and stop wide open.

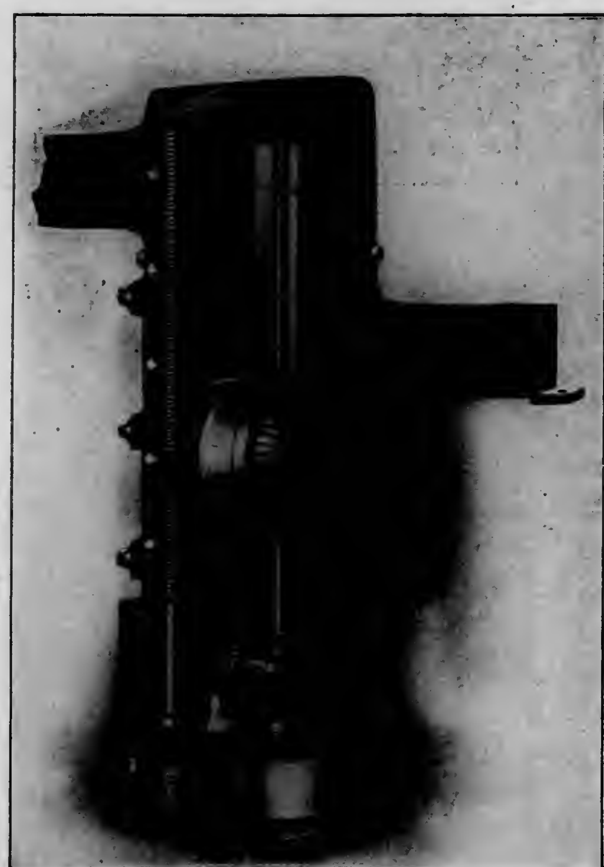
The bed is a steel casting and the crosshead travels at an angle to facilitate placing the stock in the dies. The crosshead has a long bearing surface and is equipped with adjustable gibs to take up wear. The gears are machine cut and the bearings are bushed with bronze.

While the machine is primarily intended for bending purposes, it may also be used as a press or shear. The rapid motion of the crosshead makes it possible to obtain a greater output and where the stock will stand a cold bend a considerable saving may be made in fuel.

Don't Be Afraid to Ask Questions.—If one is not in full possession of knowledge of any particular detail, it is the greatest mistake not to ask questions so as to become so. It is not a lowering of dignity, nor an indication of incompetency to have to ask for such information, in fact, much can often be learned from even the men of the lowest grade by intelligent questioning. Any other principle of conduct usually results in an ostrich act on the part of the one who attempts it, his ignorance being easily apparent.—*W. J. Harahan, before the New York Railroad Club.*

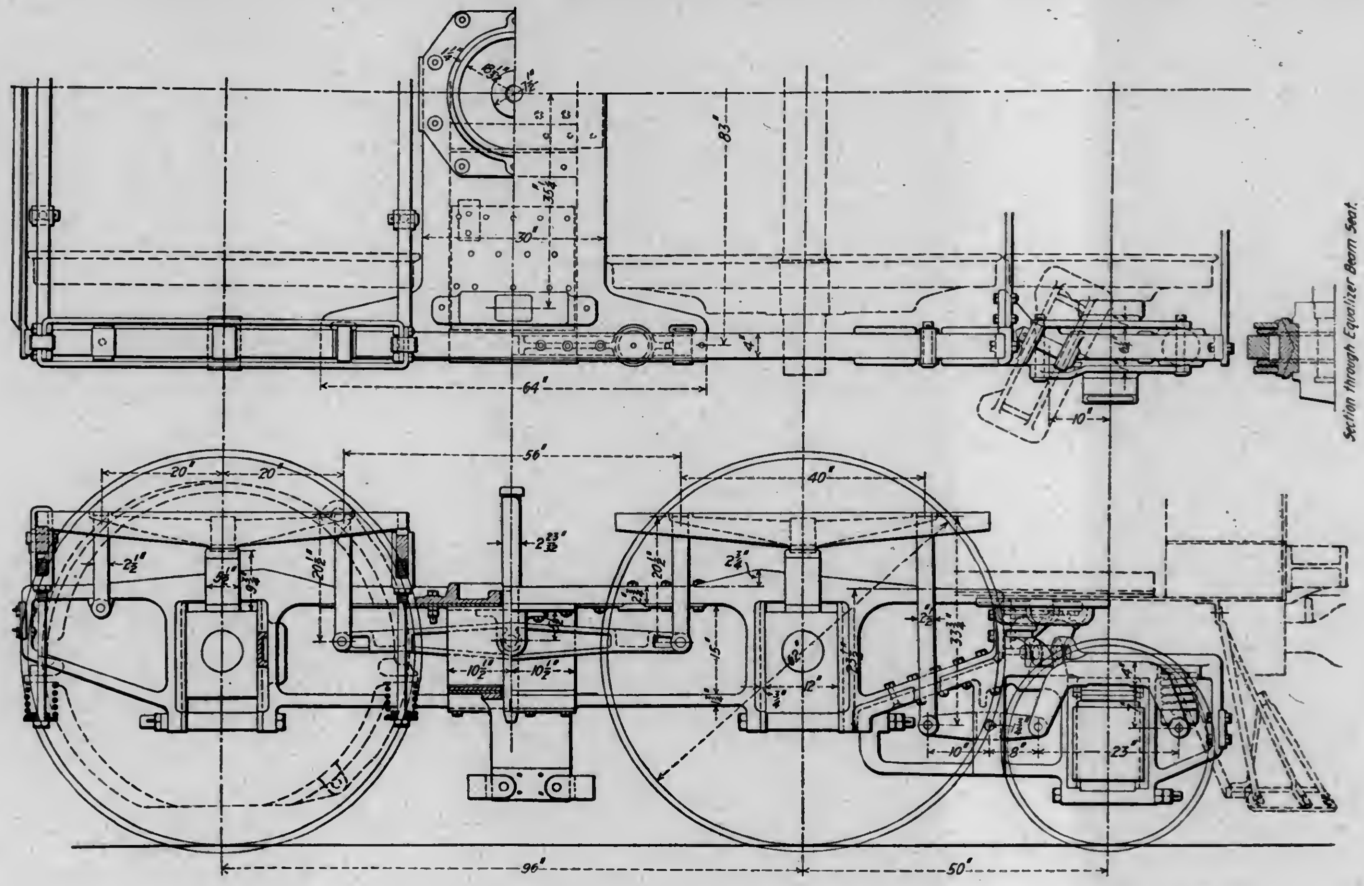
PEDESTAL FACING MACHINE.

The portable machine, shown in the illustration, was originally designed for truing up the pedestals on street and interurban car trucks, but it is also applicable for planing the pedestal jaws of locomotives. It is strong and powerful and has a milling cutter with inserted blades of high-speed steel. This cutter may



be made of any desired diameter and has an adjustment of 1½ in. to allow for different widths between the jaws and for different depths of cut. The cutter is driven from the driving shaft through a worm and worm wheel geared 42 to 1, thus furnishing a powerful and smooth motion to the cutter. A wide range of feeds is provided to suit the various conditions.

The bed of the machine, which carries the sliding head and milling cutter, is made in the form of a chuck, as shown in



ELECTRIC LOCOMOTIVE TRUCK AS ALTERED TO INCLUDE EXTRA PAIR OF WHEELS—N. Y., N. H. & H. R. R.

the illustration, with slots on both the top and bottom edges, on the back, in which the projections of the clamps, that hold the tool rigidly to the pedestal, fit. Adjusting screws are fitted in the center of these clamps and go through and clamp the whole device to the back of the leg without springing the bed, or the work to be milled. At the top and bottom edges are shown six set screws for holding the machine edgeways and these in conjunction with the clamps hold the machine firmly to the work.

Parallel jaws are not the only ones which this tool will mill, for by placing wedge-shaped pieces in the chuck the machine will mill the side having a taper equally as well. It is thus easy to establish and maintain a standard taper. For very wide jaws a parallel piece is used between the chuck and the pedestal to which it is clamped.

The standard cutter is 8¾ in. in diameter and is capable of taking a deep cut. It is adjusted by a socket wrench which fits into and operates a cross-feed screw in the center of the cutter, moving it in or out and still retaining a long bearing for the shaft and driving device. The head has 20 in. travel.

The machine is ordinarily belt driven, but the drive shaft end can be fitted to use an air drill or any portable power. Various sizes are built to meet requirements; the machine is manufactured by H. B. Underwood & Co., of Philadelphia, Pa.

CASCADE TUNNEL ELECTRIFICATION.—Announcement is made that electrically propelled passenger trains will be running through the Cascade tunnel of the Great Northern Railway in Washington before January 1. Turbines and transformers to develop 12,000 horse power are being erected in the power house at Leavenworth and the wood stave pipe line which is to carry a considerable portion of the Wenatchee River to the turbines is ready for service. This pipe line is 10,950 feet in length and eight feet six inches in diameter, inside measurement. It is the largest job of its kind ever undertaken in the Northwest. Eight electric locomotives, which are illustrated elsewhere in this issue, will be used for pulling trains through the tunnel.

APPLICATION OF EXTRA TRUCK WHEELS TO ELECTRIC LOCOMOTIVE.

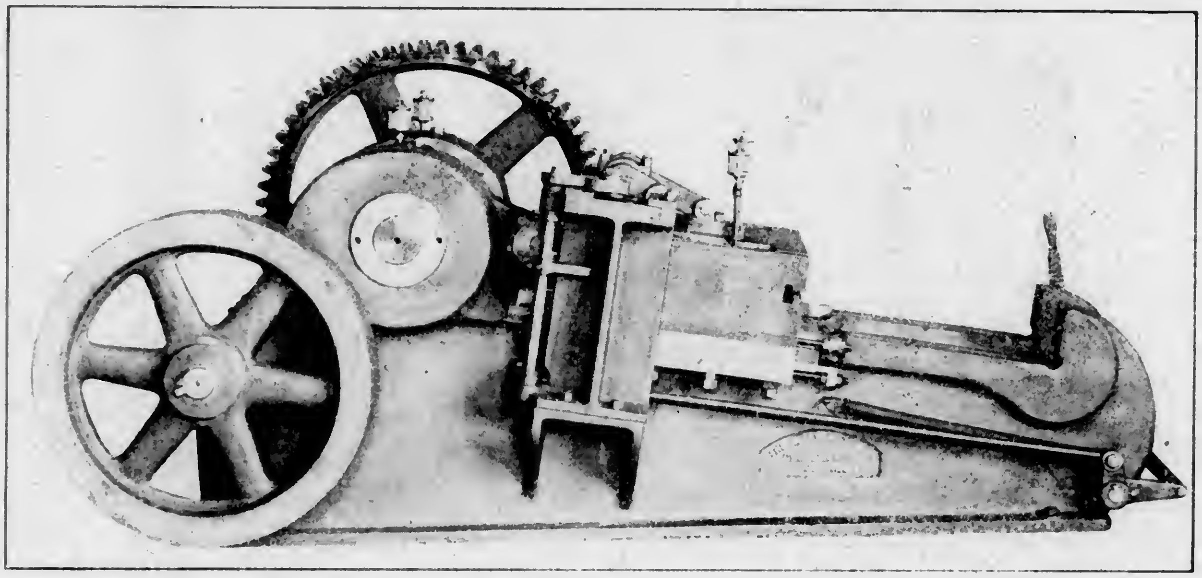
The New York, New Haven & Hartford Railroad is operating all of its trains between Stamford, Conn., and the Grand Central Station, New York, by electric locomotives of the single phase type, taking current from an overhead trolley system. These locomotives were fully illustrated and described on page 396 of the October, 1907, issue of this journal.

After the locomotives had been in service a short time it was found that the weight on driving wheels was somewhat excessive and that when operating on a tangent the nosing effect of the large four wheel trucks was very annoying. Both of these difficulties have now been corrected by the application of an extra truck wheel on the outside end of each of the driving trucks, the arrangement of which is shown in the accompanying illustration.

This application consists simply of a supplementary frame, which is bolted to and forms part of the main frames of the truck and includes a radial side bearing of special construction. This is of the rocking instead of sliding type and hence offers minimum resistance to the turning motion around the center pin, and is at the same time able to carry considerable weight. The extra truck wheels are about 33 in. in diameter, and on account of the small space available, are set very close to the driving wheel. The equalizer system of the main truck is continued to permit the extra truck assuming its share of the weight.

It is understood that this application has completely cured the trouble, and that it will be applied to all the present and future locomotives of this type on this road.

FOREST PRESERVATION IN JAPAN.—About 60 per cent. of the total area of Japan is occupied by carefully preserved forests. For many centuries the governing authorities of the empire have left nothing undone to conserve the forestry areas. At present the forests that are immediately under government supervision aggregate 58,000,000 acres.



AJAX HIGH SPEED STOP MOTION BULLDOZER.

HIGH SPEED, STOP MOTION BULLDOZER.

A new style bending machine, known as a high speed, stop motion bulldozer, and embodying a number of improvements over the old style, slow motion machines, has recently been placed on the market by the Ajax Manufacturing Company of Cleveland. It is specially designed for bending work cold. These machines are being manufactured in six sizes, from No. 1 to No. 6; the general dimensions of the largest and smallest and one of the intermediate sizes are given in the following table:

	No. 1	No. 3	No. 6
Floor space	5' x 2' 2"	10' x 3' 6"	15' x 7' 6"
Face of crosshead	16" x 4"	28" x 8"	60" x 10"
Travel of crosshead	5" to 8"	5" to 10"	5" to 14"
Travel of crosshead, std.	5"	8"	10"
Approximate weight of machine	2,200 lbs	9,500 lbs	24,000 lbs

A 5/8 x 3 in. arch bar, with a set of 8 in., was recently bent cold in a No. 3 machine; the four bends were easily made in one operation.

The most important features of the new machine are the rapid movement of the crosshead and the control which the operator has over it at all times. The crosshead makes 60 strokes per minute for the No. 1 size and 45 strokes per minute for the No. 6, or largest size. The machine may be thrown into operation by either a foot pedal or a hand lever, which causes the crosshead to make a complete stroke and stop wide open.

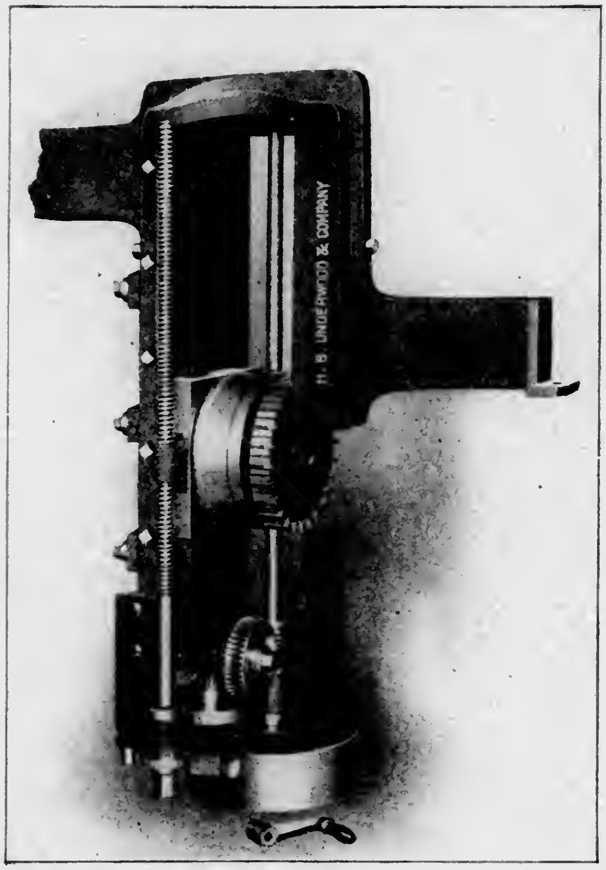
The bed is a steel casting and the crosshead travels at an angle to facilitate placing the stock in the dies. The crosshead has a long bearing surface and is equipped with adjustable gibs to take up wear. The gears are machine cut and the bearings are bushed with bronze.

While the machine is primarily intended for bending purposes, it may also be used as a press or shear. The rapid motion of the crosshead makes it possible to obtain a greater output and where the stock will stand a cold bend a considerable saving may be made in fuel.

DON'T BE AFRAID TO ASK QUESTIONS.—If one is not in full possession of knowledge of any particular detail, it is the greatest mistake not to ask questions so as to become so. It is not a lowering of dignity, nor an indication of incompetency to have to ask for such information, in fact, much can often be learned from even the men of the lowest grade by intelligent questioning. Any other principle of conduct usually results in an ostrich act on the part of the one who attempts it, his ignorance being easily apparent.—*W. J. Harahan, before the New York Railroad Club.*

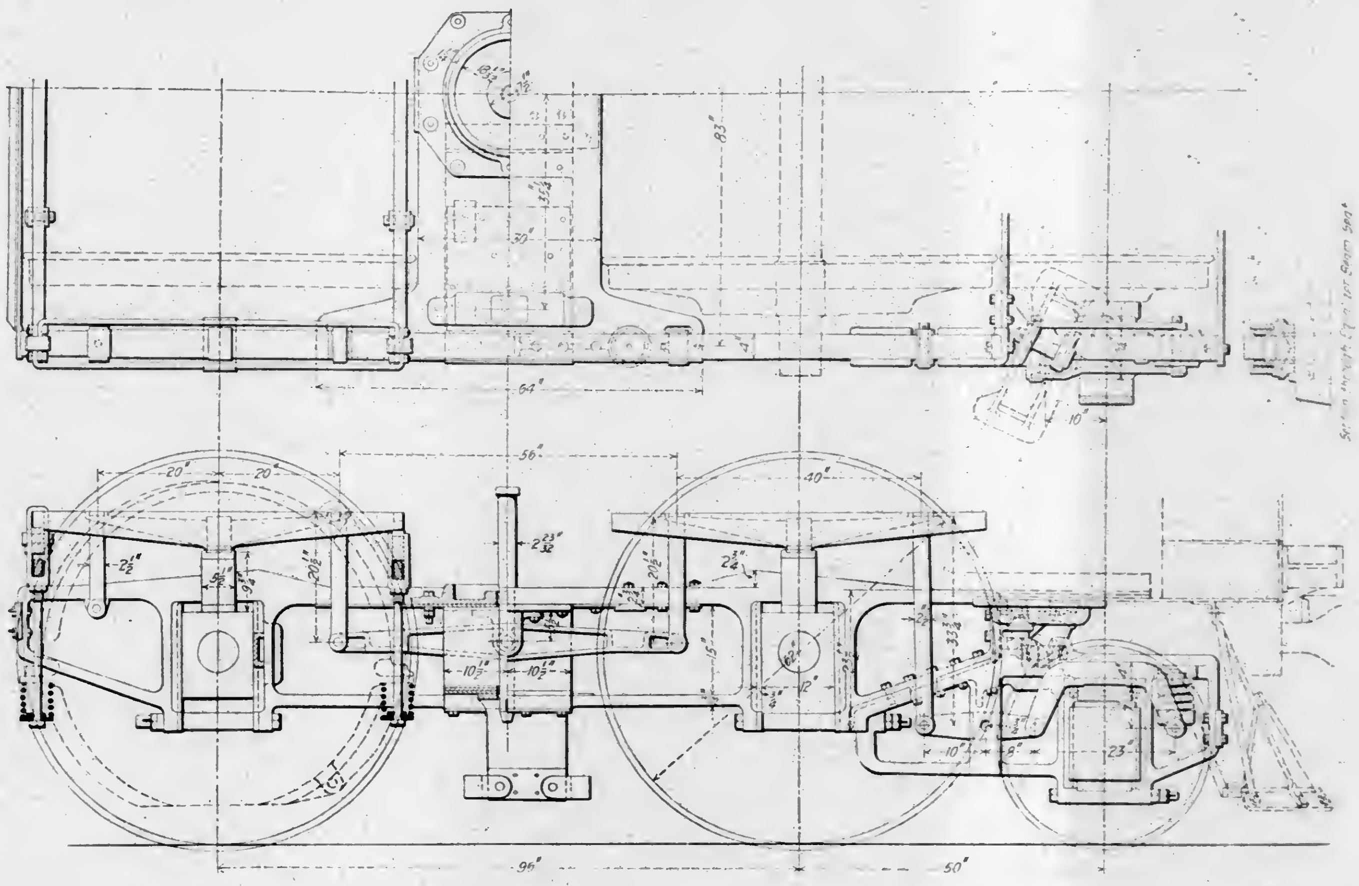
PEDESTAL FACING MACHINE.

The portable machine, shown in the illustration, was originally designed for truing up the pedestals on street and interurban car trucks, but it is also applicable for planing the pedestal jaws of locomotives. It is strong and powerful and has a milling cutter with inserted blades of high-speed steel. This cutter may



be made of any desired diameter and has an adjustment of 1½ in. to allow for different widths between the jaws and for different depths of cut. The cutter is driven from the driving shaft through a worm and worm wheel geared 42 to 1, thus furnishing a powerful and smooth motion to the cutter. A wide range of feeds is provided to suit the various conditions.

The bed of the machine, which carries the sliding head and milling cutter, is made in the form of a chuck, as shown in



ELECTRIC LOCOMOTIVE TRUCK AS ALTERED TO INCLUDE EXTRA PAIR OF WHEELS—N. Y., N. H. & H. R. R.

the illustration, with slots on both the top and bottom edges, on the back, in which the projections of the clamps, that hold the tool rigidly to the pedestal, fit. Adjusting screws are fitted in the center of these clamps and go through and clamp the whole device to the back of the leg without springing the bed, or the work to be milled. At the top and bottom edges are shown six set screws for holding the machine edgeways and these in conjunction with the clamps hold the machine firmly to the work.

Parallel jaws are not the only ones which this tool will mill, for by placing wedge-shaped pieces in the chuck the machine will mill the side having a taper equally as well. It is thus easy to establish and maintain a standard taper. For very wide jaws a parallel piece is used between the chuck and the pedestal to which it is clamped.

The standard cutter is 8¾ in. in diameter and is capable of taking a deep cut. It is adjusted by a socket wrench which fits into and operates a cross-feed screw in the center of the cutter, moving it in or out and still retaining a long bearing for the shaft and driving device. The head has 20 in. travel.

The machine is ordinarily belt driven, but the drive shaft end can be fitted to use an air drill or any portable power. Various sizes are built to meet requirements; the machine is manufactured by H. B. Underwood & Co., of Philadelphia, Pa.

CASCADE TUNNEL ELECTRIFICATION.—Announcement is made that electrically propelled passenger trains will be running through the Cascade tunnel of the Great Northern Railway in Washington before January 1. Turbines and transformers to develop 12,000 horse power are being erected in the power house at Leavenworth and the wood stave pipe line which is to carry a considerable portion of the Wenatchee River to the turbines is ready for service. This pipe line is 10,950 feet in length and eight feet six inches in diameter, inside measurement. It is the largest job of its kind ever undertaken in the Northwest. Eight electric locomotives, which are illustrated elsewhere in this issue, will be used for pulling trains through the tunnel.

APPLICATION OF EXTRA TRUCK WHEELS TO ELECTRIC LOCOMOTIVE.

The New York, New Haven & Hartford Railroad is operating all of its trains between Stamford, Conn., and the Grand Central Station, New York, by electric locomotives of the single phase type, taking current from an overhead trolley system. These locomotives were fully illustrated and described on page 396 of the October, 1907, issue of this journal.

After the locomotives had been in service a short time it was found that the weight on driving wheels was somewhat excessive and that when operating on a tangent the nosing effect of the large four wheel trucks was very annoying. Both of these difficulties have now been corrected by the application of an extra truck wheel on the outside end of each of the driving trucks, the arrangement of which is shown in the accompanying illustration.

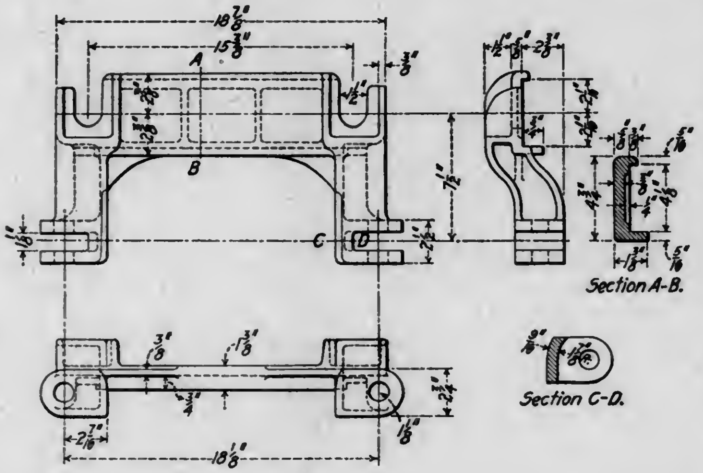
This application consists simply of a supplementary frame, which is bolted to and forms part of the main frames of the truck and includes a radial side bearing of special construction. This is of the rocking instead of sliding type and hence offers minimum resistance to the turning motion around the center pin, and is at the same time able to carry considerable weight. The extra truck wheels are about 33 in. in diameter, and on account of the small space available, are set very close to the driving wheel. The equalizer system of the main truck is continued to permit the extra truck assuming its share of the weight.

It is understood that this application has completely cured the trouble, and that it will be applied to all the present and future locomotives of this type on this road.

FOREST PRESERVATION IN JAPAN.—About 60 per cent. of the total area of Japan is occupied by carefully preserved forests. For many centuries the governing authorities of the empire have left nothing undone to conserve the forestry areas. At present the forests that are immediately under government supervision aggregate 58,000,000 acres.

BRAKE HANGER CARRIER.

The breaking of carrier irons on the usual arch bar type of truck requires the removal of the car to the repair track where it can be jacked up and the truck removed in order to allow the removal of the column bolts for the application of a new casting. The carrier shown in the accompanying illustration has been designed by W. H. Hall, chief car inspector of the Central



Railroad of New Jersey, at Jersey City, N. J., for the purpose of eliminating the delay and labor of renewing broken carriers. It is designed so that it can be fitted without removing the truck from beneath the car and hence without the necessity of putting the car on the repair track. The bolt holes are slotted and a lip is provided for fitting down over the outer side of the arch bar and it can be applied by simply loosening the column bolt nuts and driving the bolt up slightly to permit slipping it into place.

NEW RATCHET JACK.

The rapidity of operation has made the ratchet type of jack a very popular device up to the limit of its capacity, which has

usually been considered 15 tons or under. With this weight in the ordinary designs, the crushing strength of the pawl or teeth is reached, and this type of jack is usually used under this load only in case of necessity.

Recognizing these limits, the Buda Foundry & Mfg. Co., Railway Exchange Building, Chicago, has designed a new ratchet jack, shown in the accompanying illustration, which has a very large factor of safety under 15 tons and is capable of lifting 20 tons with perfect safety. The change made in this design, in addition to the use of the best materials, heavier general construction and very accurate workmanship, consists of special pawls which have triple teeth and thus divide the stress over three teeth in the rack and produce a comparatively light strain on each. Considerable improvement has also been made in the design of the fulcrum pin, which has not only been enlarged and constructed of tempered high carbon steel, but is arranged with a bearing of special design to assist in resisting the shearing stress. The lower part of the lever, through which the pin extends, is arranged to contain a shoulder and the bushing around the pin, which extends through the frame, is continued over the shoulder of the lever and thus supports the fulcrum pin between the lever and the frame.

This jack is single acting, the load being raised on the downward stroke of the lever. An improved arrangement for changing the direction of the lifting bar has been adopted and by a special design the uniform engagement of the triple teeth of the pawls has been assured. The frame and small working parts of the jack are of malleable iron; the lever is of open hearth steel; the rack of high carbon open hearth steel; the pawls are case hardened drop forgings and the fulcrum pin is of high carbon steel tempered and ground.

A test to show the mechanical efficiency of the jack gave a record of 77 per cent. It is said that the ordinary ratchet jacks show about 40 per cent. mechanical efficiency. This jack is given a rated capacity of 20 tons; is 28 in. high in the lowered position; has a 16 in. rise of bar and weighs 135 lbs.

RECORD BREAKING SWITCH-BOARD BUILDING.

The central telephone exchange, at Paris, was completely destroyed by fire on September 21, 1908. Since this completely paralyzed the telephone communication in the city it was imperative that it should be replaced in the shortest possible time. After bids had been presented by all of the larger switchboard manufacturers of the world, the contract was given to the Western Electric Company, who, in spite of the enormous handicap of shipment half way across the United States and across the Atlantic Ocean, were able to promise a delivery of the switchboard, in working order, inside of sixty days, agreeing to a very heavy daily penalty for any excess of that time. This required exceedingly accurate planning and rapid work on the part of this company, as will be appreciated when it is stated that the switchboard is 180 ft. long, requires 90 operators to operate it and will accommodate more than 10,000 subscribers. The back of the board contains about a million soldered connections and about 3,000 miles of wire. In addition to this the company also furnished 135,000 ft., or something more than 25 miles of switchboard cable. The manufacture of the board was principally done at the Hawthorne works of the company near Chicago and the shipment from that point required 234 boxes. About 40,000 feet of lumber were used in packing the complete board and 10,000 sq. ft. of paraffine paper were used in waterproofing the packing cases for the cables.

Definite information concerning this order was received by the New York office of this company on October 3 and the completed switchboard was shipped from Chicago on October 26. This shipment was greatly facilitated by the co-operation of the Grand Trunk and the Delaware, Lackawanna & Western Railways, who delivered the six cars at Hoboken but two days after they were loaded at Hawthorne. The shipment then left New York on board a French line steamship on October 29, which was but a few days more than a month after the fire occurred. It reached Paris on time and was installed well within the contract requirement.

PERSONALS.

P. J. Conrath has been appointed master mechanic of the Missouri Pacific Ry. at De Soto, Mo.

George J. Duffy has been appointed assistant master mechanic of the Lake Erie & Western Ry. at Lima, Ohio.

D. D. Robertson has been appointed master mechanic of the Wyoming division of the Lehigh Valley R. R., succeeding A. M. Gill.

A. J. Wade has been appointed master mechanic of the Louisiana & Arkansas Ry. at Stamp, Ark., succeeding F. A. Symonds, resigned.

G. W. Foster has been appointed general foreman of shops of the Lake Erie, Alliance & Wheeling Ry. at Alliance, Ohio, succeeding W. S. Jackson, resigned.

M. M. Myers, master mechanic of the Missouri Pacific Ry. at De Soto, Mo., has been transferred to Osawatomie, Kan., succeeding Mr. Tutt.

A. M. Gill, master mechanic of the Wyoming division of the Lehigh Valley R. R., has been promoted to general inspector of motive power and rolling stock.

D. E. Meyers has been appointed foreman of the motive power and car departments of the Louisiana & Arkansas Ry., with office at Minden, La., succeeding J. B. Baird, resigned.

Samuel Millican, superintendent of motive power for the Houston & Texas Central Ry. and the Houston East & West Texas Ry., died at Dallas, Tex., on October 22, from a stroke of paralysis.

F. K. Tutt, master mechanic of the Missouri Pacific and the St. Louis, Iron Mountain & Southern Rys. at Osawatomie, Kan., has been appointed master mechanic at St. Louis, succeeding J. J. Reid, resigned.

J. T. Connor has been appointed acting superintendent of motive power and machinery of the Houston, East & West Texas, Houston & Texas Central and Houston & Shreveport Rys., succeeding S. Millican, deceased.

J. D. Harris, formerly works manager of the Westinghouse Air Brake Company, Wilmerding, Pa., has been appointed superintendent of motive power of the Baltimore & Ohio Railroad, with headquarters at Baltimore, Md.

R. E. Smith, road foreman of engines of the Canadian Pacific Ry. at Medicine Hat, Alb., Can., has been appointed master mechanic of the Second district, with headquarters at Medicine Hat, his former position having been abolished.

Allen Vail, master mechanic, Buffalo shop, of the Pennsylvania R. R., has been retired on a pension and the jurisdiction of J. M. James, master mechanic, Olean shop, has been extended to include the entire Buffalo and Allegheny division. Mr. James will transfer his office to Buffalo.

C. F. Smith has been appointed master mechanic in charge of all steam and electrical equipment of the Tombigbee Valley Ry., with office at Calvert, Ala. Mr. Smith for the last three years has been special representative for the Cataract Refining Co., Buffalo, N. Y.

H. Wade Hibbard, professor of mechanical engineering of railways at Sibley College, Cornell University, has resigned to take effect at the end of the first semester, at which time he will take up the duties as head of the mechanical department of the University of Missouri. Professor Hibbard has been at Cornell since 1898 and organized the railway mechanical engineering department of that university.

Alfred R. Kipp has been appointed superintendent of motive power and cars of the Wisconsin Central Ry., succeeding W. G. Menzel, resigned. Mr. Kipp was formerly master mechanic of the Wisconsin Central Ry. and has also been with The Arnold Co., Chicago.

Edward Elden, formerly master mechanic of the New York Central & Hudson River R. R. and the Lake Shore & Michigan Southern R. R. at Buffalo, N. Y., has accepted a position with the Dodge Manufacturing Co., Mishawaka, Ind., as chief of sales of the railroad department.

THE RAILWAY BUSINESS ASSOCIATION.

This association has taken up the work of urging that everyone interested in the speedy return to activity of transportation interests, and a resumption on the part of the railroads of purchases of material and equipment, will at once address demands upon their legislative representatives in State and National capitols for reasonable enactments and for a favorable attitude toward a fair adjustment of rates. That the campaign is to be an aggressive one is indicated by the selection of G. M. Basford, assistant to the president of the American Locomotive Company, as acting secretary. Mr. Basford will give undivided attention for several months to the effort which the Association is making to show the public that anything hurting railroads also hurts whole communities of people directly, and hosts of others indirectly, and that there is immediate necessity for a change toward moderation and calmness in railroad legislation.

BOOKS.

Mechanical World Electrical Pocket Book for 1909.—Pocket size, 4¼ x 6¼. 208 pages. Published by Emmott & Co., 65 King street, Manchester, England. Price, 15 cents, net.

This is the second issue of the separate Electrical Pocket Book, which was formerly included as part of the Mechanical World Pocket Diary and Year Book. It has been greatly enlarged and improved and now contains a very complete and valuable collection of electrical engineering notes, rules, tables and data.

Application of Highly Superheated Steam to Locomotives. By Robert Garbe. Edited by Leslie S. Robertson. 6 x 9½. 66 pages. Cloth. Illustrated. Published by Norman W. Henley Publishing Co., 132 Nassau street, New York. Price, $2.50.

The excellent series of articles which first appeared in *The Engineer* (London), an extended abstract of which was published in the March and September issues of this journal, have been revised and reprinted in book form. As our readers know, these are the most valuable contributions on this subject which have ever appeared in brief form and are written in an exceptionally clear-cut and convincing manner. Herr Garbe, who is Privy Counsellor of the Prussian State Railways, has probably had greater experience and is more thoroughly familiar, in a practical way, with superheated steam in locomotive practice than any other man on either continent. While this book deals with highly superheated steam the matter of low superheat is thoroughly discussed and the reasons of the author for his stand in using steam at least 180 degs. F. above saturation temperature are fully given. In addition to the theoretical discussion of the subject the book also contains full illustrated descriptions, with a discussion of the merits, of all of the better known superheaters in the world. The details of the locomotive, outside of the superheater, for satisfactorily using steam at this high temperature are discussed and the designs introduced by Herr Garbe are

illustrated. Reports on a number of very complete and practical tests form the concluding chapter of the work. This book cannot be recommended too highly to those motive power men who are anxious to maintain the highest efficiency in their locomotives.

Future Supply of Ties.—As a part of its plan for the future crosstie supply the Pennsylvania R. R. has set out this year 625,000 young trees, making a total of 2,425,000 trees set out in its campaign of reforestization.

CATALOGS

IN WRITING FOR THESE PLEASE MENTION THIS JOURNAL.

Scientific Books.—The Hill Publishing Company, 505 Pearl street, New York, is issuing a general catalog of technical books, which includes a classified list, giving the subject and author, brief comment and price, of the best known technical works.

Roller Bearings.—The Standard Roller Bearing Company, 50th street and Lancaster avenue, Philadelphia, Pa., is issuing a small leaflet calling attention to the wonderful development of anti-friction bearings during the past few years and the facilities which it maintains for manufacturing them.

Time to Get Busy.—The Cleveland Twist Drill Company is issuing a leaflet calling attention to the fact that business is rapidly increasing and that its plant is now running to full capacity. It advises those who wish to obtain a quick delivery on supplies of small tools to take the matter up right away.

Switchboard Instruments.—Bulletin No. 4627, recently issued by the General Electric Company, Schenectady, N. Y., contains matter descriptive of curve drawing instruments for alternating and direct current circuits. These instruments have recently been improved and are fully described and illustrated in this bulletin, which includes a list of prices.

Exhibit of Steel Tubes.—The National Tube Company, Pittsburgh, Pa., is issuing a pamphlet which fully illustrates and describes the very complete exhibit made by it at the Pittsburg Sesqui Centennial Exhibition. This exhibit was very attractive and interesting and contained examples of Shelby seamless steel tubing that are distorted to a surprising extent without cracking.

Air Compressors.—The Bury Compressor Company, Erie, Pa., is issuing catalog No. 42, which fully illustrates and describes the latest developments of the modern air compressor. Machines for direct steam or electric, as well as belt drives are shown for delivering air at practically any desired pressure. The specifications for each machine include a table giving the size of intake and discharge pipes, horse power required, speed and capacity of the machine, etc.

Crocker-Wheeler Company.—Among the bulletins recently issued by this company are No. 108, which gives a large amount of general information concerning alternating current, including formulæ for calculating the amperes per phase, size of generator and the importance of the power factor. No. 109 describes small generating sets ranging from 2 to 19 kw, capacity. These are direct connected with a steam engine forming the motive power. No. 106 is on the subject of direct current switchboard panels.

Jacks.—The Buda Foundry & Mfg. Company, Chicago, is issuing catalog No. 123, which contains illustrations and descriptions of a most complete collection of ball-bearing, cone-bearing, geared-ratchet, ratchet and friction jacks. These jacks are shown in all practical sizes for lifting any weight suitable to a portable equipment. One of the ratchet jacks is illustrated elsewhere in this issue. In addition to the regular line there are shown a number of special adaptations for meeting unusual conditions. All of the jacks shown in this catalog have been most carefully designed in the light of many years' practical experience.

Milling Machines, Etc.—Pratt & Whitney Co., Hartford, Conn., is issuing a catalog which illustrates and describes milling machines, die sinkers, and profilers. These machines are all precision tools adapted for high grade work. They have the latest improvements and, with few exceptions, are kept in stock and can be furnished very promptly. The illustrations of the tools, of which there are many, both general and detailed, are on a large scale and show all parts of the machine to advantage. The descriptive matter is very complete and tables of specifications in each case are included. This catalog will form a very valuable addition to the library of any one having work of this character to do. It is standard, 9 x 12, in size.

Machine Tools.—The 1909 edition of Manning, Maxwell & Moore's machine tool catalog has just been issued. It forms a large volume of 1170 pages, 9½ x 13 in. in size and contains excellent illustrations of 2570 different tools with sufficient specification and description of each to make the general features fully understandable. The grouping has been most carefully looked after, those tools of the same kind and for the same purpose being collected together, making it very convenient for any one to investigate any special line or kind. For instance, the first 93 pages of the book are devoted to strictly railroad tools, and 154 different machine tools are shown, which are not adapted for other than railroad shop use. These include wheel and axle lathes, wheel boring machines, special designs ot planers, wheel presses, high duty drills, portable presses, flue welding machines, grinding machines, horizontal boring machines, portable cylinder boring machines and many others. Other sections of the catalog also contain tools which are applicable to railroad shop use but are not specially designed for that purpose. The catalog contains a most complete and valuable index and also a full code for telegraphic communication. This catalog is said to be the only one in existence which gives a thorough presentation of modern machine tools designed for service with high speed steel and with the latest devices in electric drives. All of the tools shown are designed and intended for service under the heaviest modern demands and are strictly up to date in every respect. This catalog has been called an encyclopedia of machine tools and really forms the nearest approach to this definition of any book that is published. The excellence of the illustrations and other typographical work is noticeable and adds its full share to the value of the catalog.

NOTES.

Arch N. Campbell announces that he has established an office at 90 West street, New York, and will handle general railway supplies of all kinds. Mr. Campbell was formerly with the Columbia Refining Company.

Nernst Lamp Company.—After a comparative test, in practical service, of several different makes and types of lamps the proprietors of one of the largest department stores in Pittsburgh have installed 3-glowers Westinghouse Nernst Lamps.

National Boiler Washing Company.—Mr. White, president of this company, sailed on the steamship *Lusitania* November 25 for England and the Continent, where he will devote his time to the interests of this system of boiler washing.

Forged Steel Wheel Company.—The Pittsburgh Railway Company has placed an order for 6,000 forged steel wheels with the above company. These wheels will be delivered during the coming year. The plant of this company, which is closely identified with the Standard Steel Car Co., is located at Butler, Pa.

Protectus Company.—C. H. Spotts, formerly manager of the paint department, and W. F. Swearer, assistant at the general offices of the Joseph Dixon Crucible Company, are now associated with the Protectus Company, Mr. Spotts as secretary and Mr. Swearer as New York manager. The office of this company is at 30 Church street, New York.

Steel Passenger Coaches Ordered.—The Pennsylvania Railroad has placed orders for 77 all-steel passenger cars. This is in addition to orders for 200 of these cars which were placed some time ago and of which about 110 are now in service. Of the latter order 31 will be made by the Pressed Steel Car Company, 29 by the American Car & Foundry Company, and 17 by the Standard Steel Car Company.

Bettendorf Axle Company.—E. E. Silk, formerly associate editor of this journal, who for the past seven years has been in the railway supply business in New York and Chicago, is now connected with the Bettendorf Axle Company and will have offices at 1170 Old Colony Bldg., Chicago. Mr. Silk has had a very wide and valuable experience in connection with the mechanical department of railroads.

Crocker-Wheeler Company.—The Estey Organ Co., the largest organ manufacturer in the world, is installing electric drives throughout its works at Brattleboro, Vt. The contract for the electrical section of this work has been given to the Crocker-Wheeler Company and includes an order for fifty-seven induction motors ranging from ½ to 75 h. p. The current will be purchased from outside sources.

American Brake Shoe & Foundry Company.—Warren L. Boyer, formerly with the Peckham Truck Company, and later on with the New York Car & Truck Company, at Kingston, N. Y., has become associated with the American Brake Shoe & Foundry Company as assistant in the engineering department. His duties will be to look after the standardization of brake heads and brake shoes on the lines of the standards of the American Street & Interurban Railway Association.

New Car Building Plant.—The contracts have been let for the new car building and repair plant of the International Car Company, Maison Blanche Building, New Orleans, La., and bids are now being received for the machinery to equip it. The plant will be a comparatively large one, including a planing mill 60 x 100 ft., a blacksmith shop 60 x 75 ft., machine shop 60 x 60 ft., power house 60 x 100 ft., two open work shops 80 x 600 ft., and an office building. Mr. A. T. La Baron is vice-president and general manager of this company.